

TOBACCO OUTLET DENSITY, PROXIMITY, AND TOBACCO USE AMONG  
AFRICAN AMERICAN YOUNG ADULTS IN BALTIMORE CITY: MECHANISMS  
OF ACTION

by  
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## **Abstract**

Objectives: Research exploring the relationship between tobacco use and exposure to tobacco outlets via density and proximity is inconclusive, and no studies focus exclusively on African American young adults – although this population is often the target of tobacco advertisements and exposed to higher levels of tobacco outlet density. To better understand the relationship between tobacco outlet exposure and tobacco use among African American young adults research is needed on the mechanisms driving this relationship. This study explored three specific mechanisms – moderation, mediation, and growth. The specific aims of this investigation were 1. to assess the moderating role of gender in the relationship between tobacco outlet exposure (i.e., density and proximity to outlets) and past month tobacco use among African American young adults living in Baltimore City, Maryland. 2. to assess the mediating role of perceived harmfulness and disapproval of cigarette use in the relationship between tobacco outlet exposure and past month tobacco use among African American young adults living in Baltimore City, Maryland, and 3. to assess the correlation between the growth of tobacco outlet density and past month tobacco use among African American young adults living in Baltimore City, Maryland. Methods: Each aim used data from the Johns Hopkins Second Generation Baltimore Prevention Program (BPP) cohort. The BPP is a field trial of two universal first grade interventions, respondents are predominately African American, and were followed through adulthood. Assessments of tobacco and other drug use began in the sixth grade. Geospatial methods were used to determine the density of tobacco outlets surrounding participants' homes', as well as how close participants' lived to the nearest tobacco outlet. Aim 1 was assessed using logistic regression models via generalized

estimating equations. Aim 2 was assessed using path analyses. Aim 3 used parallel process growth curve modeling to assess the simultaneous growth of tobacco outlet density and past month tobacco use. Results: In Aim 1, sex modified the relationship between tobacco outlet density and past month tobacco use, and this relationship was only significant among women, such that after adjusting for confounding, the relationship between past month tobacco use and tobacco outlets that sold tobacco but not alcohol was positive and significant (aOR = 1.02;  $p < 0.05$ ). Additionally, among women, the relationship between past month tobacco use and tobacco outlets that sold both tobacco and alcohol was positive and significant (OR = 1.04;  $p < 0.05$ ), however, after adjusting for confounding the relationship was no longer statistically significant (aOR = 1.04;  $p = 0.12$ ). Proximity to the nearest tobacco outlet was not significantly associated with past month tobacco use for men or women. On average, people lived closer to and the density per quarter mile was higher for outlets that sold tobacco, but not alcohol, relative to outlets that sold both tobacco and alcohol. For example, on average, people lived within 552 meters (standard deviation [SD] = 459 meters) of an outlet that sold tobacco, but not alcohol, and within 658 meters (SD = 500 meters) of an outlet that sold both tobacco and alcohol. Furthermore, there were on average 16.4 outlets per quarter mile (SD = 26.4) that sold tobacco only, whereas the average density for outlets that sold both tobacco and alcohol was 7 outlets per quarter mile (SD = 11.3). In Aim 2, disapproval of cigarette use, but not perceived harmfulness of cigarette use was a significant mediator in the relationship between tobacco outlet density and past month tobacco use, and results varied by gender, such that disapproval of cigarette use significantly mediated the relationship between tobacco outlet density and past month tobacco use for men but not

women. The relationship between proximity to the nearest tobacco outlet and past month tobacco use was not mediated by disapproval or perceived harmfulness of cigarette use for men or women. In Aim 3, correlations between several growth factors were evaluated, of primary interest was the correlation between the random effects on the slopes of past month tobacco use and tobacco outlet density. This relationship was not significant ( $r = 0.31$ ;  $p\text{-value} = 0.08$ ). However, the correlation between the random effects on the intercepts of past month tobacco use and tobacco outlet density was statistically significant ( $r = 0.19$ ;  $p\text{-value} < 0.05$ ). Conclusions: This study has implications for research, practice and policy. For example, public health practitioners aiming to reduce tobacco use among African American young adults living in areas where tobacco outlet density is high should consider gender-specific interventions as this study implies that the relationship between tobacco outlet density and tobacco use, to include mediating factors, differ by sex. Furthermore, policy should focus on zoning restrictions that prevent the establishment of tobacco outlets in residential neighborhoods, recognizing that neighborhoods where tobacco outlet density is initially high may be associated with initial decisions to use tobacco among African American young adults. Future research should continue evaluating mechanism driving the relationship between exposure to tobacco outlets and tobacco use among this population. Such research will potentially reveal other mediators and moderators that are malleable to intervention, and this will lead to comprehensive preventive efforts that impose restrictions on tobacco outlet density and zoning, while simultaneously addressing other correlates of tobacco use.

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## **Chapter 1: Introduction**

### **1.1 Problem Statement**

The relationship between exposure to tobacco outlets (i.e., density and proximity to outlets) and tobacco use is gaining attention in the literature. However, results are mixed with regard to whether or not tobacco outlet density, proximity, or both are associated with tobacco use. Important to this discourse are the mechanisms driving the relationship between exposure and use, but research exploring these mechanisms is sparse.

This dissertation, in three primary manuscripts, elucidates the underlying mechanisms of the relationship between tobacco outlet exposure and tobacco use among African American young adults living in Baltimore City, Maryland. The mechanisms explored are moderation, mediation, and growth. The first manuscript explores gender as a moderator in the relationship between tobacco outlet exposure and tobacco use. This is important because social norms related to tobacco access behavior differ for men and women (Difranza, Savageau, & Aisquith, 1996; Leatherdale & Strath, 2007; Proctor, Barnett, & Muilenburg, 2012; Robinson, Klesges, & Zbikowski, 1998), and females may be more vulnerable to environmental correlates of tobacco use relative to men (Brown et al., 2014). The second manuscript explores perceived harmfulness and disapproval of cigarette use as potential mediators in the relationship between tobacco outlet exposure and tobacco use. Social cognitive theory posits that behaviors, cognition, and the environment are inextricably linked (Bandura, 1986). Based on this theory, it is plausible that young adults may interpret the widespread availability of tobacco outlets as normative, which may influence them to approve of tobacco use and underestimate the

risk associated with smoking. No study to date has explored potential mediators of the relationship between tobacco outlet exposure and tobacco use. Identifying mediating and moderating factors can lend to the development of preventive interventions. The final manuscript explores the parallel growth of tobacco outlet density and past month tobacco use in residential neighborhoods. This is important because it will yield empirical evidence on whether or not changes in tobacco outlet density over time are associated with changes in tobacco use. This information can be of importance to policy makers and advocates aiming to reduce tobacco outlet density in residential neighborhoods. These three manuscripts are guided by the following research questions and specific aims:

## **1.2. Research Questions**

1.2.1. Does gender moderate the relationship between tobacco outlet exposure (i.e., density and proximity to outlets) and past month tobacco use among African American young adults living in Baltimore City?

1.2.2. Are perceived harmfulness and disapproval of cigarette use mediators of the relationship between tobacco outlet exposure and past month tobacco use among African American young adults living in Baltimore City?

1.2.3. Are changes in tobacco outlet density and past month tobacco use correlated over time among African American young adults living in Baltimore City?

## **1.3. Specific Aims:**

1.3.1. To assess the moderating role of gender in the relationship between tobacco outlet exposure (i.e., density and proximity to outlets) and past month tobacco use among African American young adults living in Baltimore City, Maryland.

1.3.2. To assess the mediating role of perceived harmfulness and disapproval of cigarette use in the relationship between tobacco outlet exposure and past month tobacco use among African American young adults living in Baltimore City, Maryland.

1.3.3. To assess the correlation between the growth of tobacco outlet density and past month tobacco use among African American young adults living in Baltimore City, Maryland.

#### **1.4. Public Health Significance**

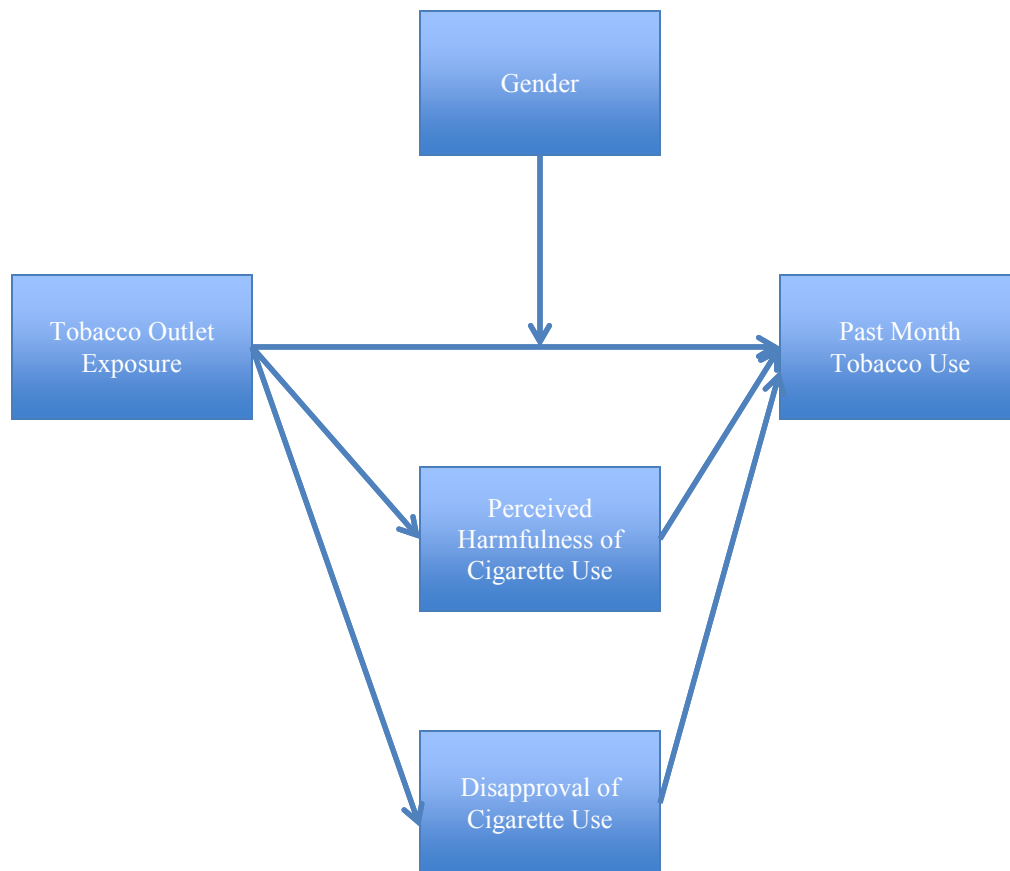
Tobacco use is a global problem. Tobacco attributed deaths are projected to reach a high of 6.4 million by 2015 – killing 50% more people than HIV/AIDS, and accounting for 10% of all deaths worldwide (Mathers & Loncar, 2006). By 2030, tobacco attributed deaths are expected to increase to 8.3million (Mathers & Loncar, 2006). Tobacco use is a key determinant of poor health across the life course and individual level interventions are at best modestly effective in the long-term (Roberts et al., 2014) elucidating the need for population level interventions such as those aimed to reducing tobacco outlet density in residential neighborhoods. Furthermore, despite the decline in tobacco use over the past decade in the US, the percentage of young adults 18 to 25 years who smoke is higher than any other age group (SAMHSA, 2012), and in some African American communities in Baltimore, more than 50% of young adults smoked cigarettes (Smith et al., 2007).

This dissertation will elucidate built environmental correlates of tobacco use (i.e., exposure to tobacco outlets) among young adults from a vulnerable population, as well as the mechanisms driving this relationship. The primary public health implication of this study relates to tobacco control policy. This research will map the location of tobacco outlets, determine the density, and assess how close young adults live to tobacco outlets,

and compare this information to trends in tobacco use (i.e., past month tobacco use). This research may be of interest to policy makers aiming to reduce tobacco outlet density. Furthermore, this research samples African American young adults living in Baltimore City, Maryland. This is important because tobacco outlet density is typically higher in low-income, minority neighborhoods (Fakunle, Morton, & Peterson, 2010; Peterson et al., 2011; Rodriguez, Carlos, Adachi-Mejia, Berke, & Sargent, 2012b; Schneider, Reid, Peterson, Lowe, & Hughey, 2005; Yu, Peterson, Sheffer, Reid, & Schnieder, 2010). The public health implications of this dissertation also extend to research and practice. For example, the conceptual model that I am proposing lends insight into the mechanisms by which tobacco outlet exposure influences tobacco use. This will contribute to theory building and the scientific literature base in this area. Furthermore, identifying mediators and moderators of the relationship between tobacco outlet exposure and tobacco use that are malleable to preventive interventions will potentially be of value to practitioners aiming to reduce tobacco use among young adults. In summary, findings from this research can be translated into policy, theory, and practice efforts aimed at tobacco prevention and control among young adults. Figure 1.1 provides the conceptual model guiding this study.



Figure 1.1: General conceptual model



## **Chapter 2: Review of the Literature**

Tobacco use is the chief cause of preventable and premature death in the United States (Services, 2012), and is one of the world's largest public health threats ever (WHO, 2012). The US Surgeon General recommends targeting prevention efforts toward youth and young adults to stop the tobacco epidemic (Services, 2012). This population is particularly vulnerable to environmental influences to smoke (Services, 2012). However, relative to the family and peer environment, the neighborhood context has been understudied in relation to substance use among youth (Lambert, Brown, Phillips, & Ialongo, 2004). Literature examining the relationship between the built environment and tobacco use has found significant associations between tobacco use and census level factors (e.g., area level poverty) (Diez Roux, Merkin, Hannan, Jacobs, & Kiefe, 2003; Matheson et al., 2011); tobacco use and surveys of perceptions of neighborhood disorder (Brown et al., 2014; Ellaway & Macintyre, 2009; Lambert et al., 2004; Patterson, Seravalli, Hanlon, & Nelson, 2012; Wilson, Syme, Boyce, Battistich, & Selvin, 2005); and between tobacco use and systematic social observation of neighborhood disorder assessed by trained field raters (e.g. graffiti and trash in open places) (Miles, 2006). However, the relationship between tobacco use and exposure to tobacco outlets (i.e., density and proximity to outlets) is only beginning to receive attention.

High tobacco outlet density is inconsistent with public health messages that warn about the risk associated with tobacco use (Cohen & Anglin, 2009). Furthermore, research examining the effects of tobacco outlet exposure on tobacco use is inconclusive. Some studies find that higher tobacco outlet density is associated with tobacco use, while being in close proximity to tobacco outlets has no association with use (Henriksen et al.,

2008; Lipperman-Kreda et al., 2013; McCarthy et al., 2009). At least one study found that proximity, but not density, was significantly associated with tobacco use (Reitzel et al., 2011). Another study found that neither tobacco outlet density nor proximity were associated with smoking outcomes after controlling for confounders (Adachi-Mejia, Carlos, Berke, Tanski, & Sargent, 2012), while other results show that both density and proximity are significantly related to tobacco use (Chuang, Cubbin, Ahn, & Winkleby, 2005). In addition, several studies report on only one measure of exposure (i.e., either density or proximity, but not both), making it difficult to form a complete conceptual framework about both tobacco outlet density and proximity, and their independent associations with tobacco use. For example, several studies that found a positive and significant relationship between tobacco outlet density and tobacco use, did not report findings on proximity (Li, Land, Zhang, Keithly, & Kelsey, 2009; S. Lipperman-Kreda, Grube, & Friend, 2012b; Novak, Reardon, Raudenbush, & Buka, 2006; Reid, Peterson, Lowe, & Hughey, 2005), making it difficult to discern whether or not the relationship between proximity to tobacco outlets and tobacco use was found to be not statistically significant and thus not reported, or whether this relationship was simply not measured. West and colleagues (2010) reported an inverse association between proximity to the nearest tobacco and alcohol retailer, and alcohol and tobacco use, but the relationship between the density of these outlets and substance use was not reported (West et al., 2010). It is important to continue to build the literature base in this area in order to gain a more complete understanding of the relationship between tobacco outlet exposure and tobacco use. Essential to this understanding is gaining knowledge of the underlying mechanisms driving this relationship.

Three important steps in research efforts examining the role of tobacco outlet exposure and tobacco use include mapping the location of tobacco outlets, determining their density, and comparing this information to trends in tobacco related health outcomes (Cohen & Anglin, 2009). When carrying out this research, priority must be given to residential neighborhoods at high risk for tobacco outlet exposure. Disadvantage minority neighborhoods are at the highest risk for tobacco outlet exposure, considering these communities are often inundated with tobacco outlets (Fakunle et al., 2010; Peterson et al., 2011; Rodriguez, Carlos, Adachi-Mejia, Berke, & Sargent, 2012a; Schneider et al., 2005; Yu et al., 2010). Furthermore, research suggests that race is a significant moderator in the relationship between tobacco outlet density and tobacco use. For example, the positive and significant relationship between tobacco outlet density and tobacco use was higher in counties with higher percentages of African Americans in the population, relative to counties where the percentage of African Americans was lower (Reid et al., 2005).

There are limitations in the extant literature, which prevent generalizing the association between tobacco outlet exposure and tobacco use to the neighborhood level (i.e., within walking distance of a person's home) in low-income, minority communities. First, several studies focus only on the location of tobacco outlets by demographic variables (e.g., race, income), and do not assess the association between tobacco outlet exposure and tobacco use (Fakunle et al., 2010; Peterson et al., 2011; Rodriguez et al., 2012b; Schneider et al., 2005; Yu et al., 2010). Second of the studies that do assess the association between tobacco outlet exposure and tobacco use, several do not measure exposure within the neighborhood immediately surrounding the home environment (L.

Henriksen et al., 2008; Li et al., 2009; S. Lipperman-Kreda et al., 2012b; McCarthy et al., 2009; Novak et al., 2006; Pokorny, Jason, & Schoeny, 2003; Reid et al., 2005).

Environmental research on tobacco and other drug use suggest that the environment immediately surrounding where a person lives is associated with tobacco and other drug use (Brown et al., 2014; Furr-Holden et al., 2011; Lambert et al., 2004; Adam J. Milam, Furr-Holden, Harrell, Ialongo, & Leaf, 2014), thus it is important to understand the relationship between tobacco use and tobacco outlet exposure measured at the neighborhood level. Inferences made at the county or census tract level may not be generalizable to the neighborhood immediately surrounding where a person lives due to ecological fallacy. An ecological fallacy is the bias that occurs when statistical relationships at the group level (e.g., census tracts) are applied to individual level relationships (e.g., block level) (Brewer & Venaik, 2014). Simply put, what happens at the census tract level may not be representative of what people experience within a few blocks of their homes. Third, of the studies that explore the association between tobacco outlet exposure and tobacco use, none focus primarily on African American young adults.

In Baltimore City, 63.7% of the population is African American (Bureau, 2010), and reducing tobacco use is of the top priorities of the Baltimore City Health Department (Spencer, Petteway, Bacetti, & Barbot, 2011). The health department reports that there are no safe tobacco products, and set a goal to reduce the percentage of adults and teens who currently smoke by 20% by 2015 (Spencer et al., 2011). In order to reach this goal, tobacco outlets and their association with tobacco use cannot be ignored, making this dissertation timely and relevant to health priorities of this City.

**Chapter 3:** The moderating role of gender in the relationship between tobacco outlet exposure and tobacco use among African American young adults

**3.1. Abstract**

Introduction: Tobacco outlet exposure is a malleable correlate of tobacco use that has been understudied in young adults. Furthermore, potential gender differences in the relationship between tobacco outlet exposure and tobacco use warrant attention. The aim of this study is to explore the moderating role of gender in the relationship between tobacco outlet exposure (i.e., density and proximity to outlets) and past month tobacco use among African American young adults living in Baltimore City, Maryland. Methods: This cross-sectional study (n = 290) used geospatial methods to determine the number of tobacco outlets within walking distance (i.e., a quarter mile) of participants' homes, and distance to the nearest outlet. Logistic regression models via generalized estimating equations (GEE) were used to estimate whether or not gender modified the association of tobacco outlet exposure and past month tobacco use. Tobacco outlets were classified based on whether or not they were licensed to sell tobacco only (TO outlets) or tobacco and alcohol (TA outlets). Results: Sex modified the relationship between both TO and TA outlet density and past month tobacco use, and these relationships were significant only among women. Both TO outlet density (OR = 1.02;  $p < 0.01$ ), and TA outlet density (OR = 1.04;  $p < 0.05$ ) were positively associated with increased odds of tobacco use in the unadjusted analyses for women. After adjusting for confounders, the relationship between TO outlet density and tobacco use remained significant (aOR = 1.02;  $p < 0.05$ ), whereas the relationship between TA outlet density and tobacco use did not (aOR = 1.04;

$p = 0.12$ ). Proximity to the nearest tobacco outlet was not significantly associated with past month tobacco use. Conclusion: This study underscores the importance of reducing tobacco outlet density in residential neighborhoods, and is the first to evaluate the independent association of tobacco outlet exposure on tobacco use based on whether or not the outlet sold tobacco only or tobacco and alcohol. Women were more vulnerable to the influence of tobacco outlet density on tobacco use, relative to men. Understanding gender differences can help tailor environmentally based interventions aiming to reduce tobacco use among African American young adults living in the inner-city.

### **3.2. Introduction**

The built environment is an important correlate of tobacco use among youth and young adults and the influence of certain built environmental characteristics on tobacco use vary by gender (Brown et al., 2014; Lambert et al., 2004; Miles, 2006). For example, among a sample of predominately African American young adults, one year post high school, gender modified the relationship between perceived neighborhood drug involvement and tobacco use, such that for every unit increase in perceptions of neighborhood drug involvement among women the odds of tobacco use increased 49%, whereas this relationship was not significant among men (Brown et al., 2014). Among this same cohort, when participants were in the seventh through ninth grades perceptions of neighborhood violence, safety, and drug activity were associated with increased tobacco, alcohol, and marijuana use, however, mediating factors of this pathway differed by gender (Lambert et al., 2004). In a multi-city European study among people 15 years and older, women were more susceptible to environmental cues (e.g., perceptions of neighborhood safety, and systematic social observation of physical disorder) to smoke

relative to men (Miles, 2006). These results elucidate the importance of gender differences in the relationship between the built environment and tobacco use. However, one important environmental characteristic that warrants further attention is exposure to tobacco outlets (i.e., tobacco outlet density, and proximity to tobacco outlets). The goal of tobacco outlets, unlike other environmental correlates of tobacco use, is to directly increase the availability of tobacco products in communities for financial gain. Low-income, minority neighborhoods are often inundated with tobacco outlets (Fakunle et al., 2010; Hyland et al., 2003; Peterson et al., 2011; Rodriguez et al., 2012a; Schneider et al., 2005; Yu et al., 2010), and there is a positive association between tobacco outlet availability and tobacco use (Henriksen et al., 2008; Johns, Sacks, Rane, & Kansagra, 2013; Li et al., 2009; S. Lipperman-Kreda, Grube, & Friend, 2012a; Sharon Lipperman-Kreda et al., 2013; McCarthy et al., 2009; Novak et al., 2006; Pokorny et al., 2003; Reid et al., 2005; West et al., 2010). However, there is a lack of literature on gender differences in the relationship between tobacco outlet exposure and tobacco use.

Considering that social norms related to tobacco access behavior differ for men and women (Difranza et al., 1996; Leatherdale & Strath, 2007; Proctor et al., 2012; Robinson et al., 1998), it is plausible that the relationship between tobacco outlet exposure and tobacco use differs by gender. Two studies were found, which modeled gender as a moderator in the relationship between tobacco outlet exposure and tobacco use (Johns et al., 2013; Pokorny et al., 2003). Gender was not a significant modifier in either study. However, inner-city African Americans populations were not the primary focus of these studies – despite the increased concentration of tobacco outlets in minority communities (Fakunle et al., 2010; Hyland et al., 2003; Peterson et al., 2011; Rodriguez



et al., 2012a; Schneider et al., 2005; Yu et al., 2010). Furthermore, these studies did not account for tobacco outlet density or proximity relative to participants' homes. Such measures of tobacco outlet exposure are useful when making inferences about the impact of tobacco outlets in residential neighborhoods.

The current study will build upon and extend the literature base in this area in three distinct ways: First, gender differences in tobacco outlet exposure and tobacco use will be assessed among African American young adults who live in the inner-city, thus who are at high risk for tobacco outlet exposure. Second, tobacco outlet exposure will be assessed via density and proximity at the neighborhood level (e.g., within in walking distance of participants' homes) in order to allow inferences to be made about the role of tobacco outlets in residential communities. Third, tobacco outlets will be categorized based on whether or not they are licensed to sell tobacco only (TO outlets) or licensed to sell both tobacco and alcohol (TA outlets). This is important because TA and TO outlets are different such that stores that sell both tobacco and alcohol are considered alcohol outlets from a policy perspective, thus are subject to density and zoning restriction pertaining to alcohol retail (Thornton, Greiner, & Jennings, 2013), whereas stores that sell tobacco only are not bound by these regulations. Considering this distinction, the risk of tobacco use attributable to exposure to tobacco outlets may differ based on whether or not the outlets sell tobacco only versus tobacco and alcohol, and this distinction has been largely ignored in the literature. It is hypothesized that gender will moderate the relationship between tobacco outlet exposure and tobacco use, such that exposure to tobacco outlets and past month tobacco use will be positively associated for both men and women, with a stronger association among women controlling for potential confounders.

### **3.3. Methods**

#### **3.3.1. Participants**

Participants in this cross-sectional investigation were 290 African American young adults residing in Baltimore City, Maryland in 2009. The analytic sample was derived from a larger cohort of 799 students who participated in the Johns Hopkins Second Generation Baltimore Prevention Program (BPP) intervention in the first grade in 1993. The BPP is a field trial of two universal first grade interventions and respondents were followed through adulthood (Ialongo et al., 1999). Inclusion criteria for the current study was limited to African American participants who lived in Baltimore City in 2009, in order to estimate tobacco outlet exposure in the City during this same year. Additionally, 96% of participants who lived in Baltimore City in 2009 were African American, limiting the ability to detect differences in tobacco use by race.

A total of 613 participants completed the BPP interview in 2009, and 316 lived in Baltimore City. Of the 302 participants who met inclusion criteria (i.e., African Americans living in Baltimore City), approximately four percent (n=12) were missing information on a covariate of interest (i.e., history of tobacco use, or association with friends who smoke cigarettes) and were excluded from the analytic sample. Of the 613 participants interviewed in 2009, those included in the analytic sample (n = 290) did not differ significantly from those excluded (n = 323) with respect to intervention status, age, gender, ability to meet financial needs, education, past month alcohol use, or past month marijuana use. Participants did however differ by history of smoking, and affiliation with friends who smoke. Among the participants included in the sample 48% had a history of tobacco use as compared to 44% of those who were excluded ( $\chi^2 = 52.3$ , df = 2,  $p <$

0.001). However, those included in the sample were less likely to have friends who smoked cigarettes (39%) compared to those excluded (41%), ( $\chi^2 = 7.6$ ,  $df = 2$ ,  $p < 0.05$ ). High concentrations of tobacco outlets in low-income, minority neighborhoods (e.g., Fakunle et al., 2010; Hyland et al., 2003) and the positive association between tobacco outlet availability and tobacco use (e.g., Henriksen et al., 2008; Lipperman-Kreda et al., 2013) may help explain the higher percentage of past tobacco use among the 290 Baltimore City residents included in the study. Furthermore, the preference of cigarette alternatives such as little cigars among African American young adults (Jolly, 2008; Milam et al., 2013) may help explain why participants included in the study were less likely to have friends who smoked cigarettes.

### 3.3.2. Data Sources

#### 3.3.2a Baltimore Prevention Program (BPP) Data

In 1993, a total of 678 first grade students and their families, representative of the number of students entering first grade in nine public elementary schools in Baltimore City, were recruited to participate in the BPP trial to evaluate two first grade preventive interventions – a classroom centered (CC) intervention, and family-school partnership (FSP) intervention – aimed at improving academic success, reducing concentration problems, and reducing aggressive and shy behaviors (Ialongo et al., 1999). The proximal targets of both the FSP and the CC interventions were to prevent poor academic achievement, reduce concentration problems, and reduce aggressive and shy behaviors – known early risk factors for later substance use disorders (Ialongo et al., 1999). The distal targets of these interventions were to prevent risk of substance abuse, depression, and antisocial behavior (Ialongo et al., 1999). Three classrooms from each of the nine

schools were randomized to either of the two interventions arms or the control arm (standard classroom setting) of the trial (Ialongo et al., 1999). An additional 121 participants transferred into the participating schools after the baseline assessments, for a total sample size of 799. A description of the original study sample is reported in previous research (Ialongo et al., 1999). Annual assessment of tobacco and other drug use for this cohort started in the sixth grade (Wang et al., 2009; Wang et al., 2012). The Institutional Review Board at The Johns Hopkins Bloomberg School of Public Health approved this study.

#### 3.3.2b. Tobacco Outlet Data

Data on 1,184 retail establishments (e.g., smoke shops, corner stores, grocery stores) licensed to sell cigarettes in Baltimore City in 2009 were obtained from the Circuit Court for Baltimore City, Land Records and License Division office. Retail establishments for this analysis were classified based on whether or not they were licensed to sell both tobacco and alcohol (TA), or licensed to sell tobacco only (TO). Duplicate address locations were removed (n=52) based on latitude and longitude. The remaining 1,133 outlets were analyzed in this study. There were 777 outlets licensed to sell tobacco only, and 356 licensed to sell both tobacco and alcohol. The TO and TA outlets were analyzed in separate models.

#### 3.3.2c. Alcohol Outlet Data

Alcohol outlets were included in this study for the purpose of identifying outlets that were licensed to sell both tobacco and alcohol (n=356). The number of establishments licensed to sell alcohol in Baltimore City in 2009 (n=1,340) was obtained from the Board of Liquor License Commissioners for Baltimore City. Duplicate address

locations were removed (n=45) based on latitude and longitude. There were 356 sets of latitude and longitude coordinates that appeared in both the tobacco outlet data and the alcohol outlet data, and these 356 locations were classified as TA outlets.

### 3.3.3 Measures

#### 3.3.3a. Outcome

Current tobacco use was assessed via self-report. Participants who reported having used tobacco within the past month were considered current users. The BPP assessment measures recency of tobacco use using questions from the Monitoring the Future Nation Survey (Johnston, O'Malley, & Bachman, 1995) which asked participants whether or not they used tobacco within the last week, month, year, or over a year ago. Audio computer-assisted self-interview (ACASI) methods were used to assess tobacco use to promote privacy, and to obtain accurate and complete responses (Storr, Ialongo, Kellam, & Anthony, 2002). Using a binary variable, tobacco use anytime within the past month was coded 1, otherwise 0.

#### 3.3.3b. Exposure: Tobacco outlets density and proximity to the nearest tobacco outlet

There were two exposures of interest – tobacco outlets density, and proximity to the nearest tobacco outlet. The density measures were created by dividing the count of tobacco outlets within a quarter mile network buffer of participants' homes by the area of each buffer. Studies examining exposure to tobacco outlets, typically estimate walking distance between a quarter-mile and one mile (Henriksen et al., 2008; Lipperman-Kreda et al., 2013; McCarthy et al., 2009; West et al., 2010). Currently there is no gold standard to define a buffer size representative of a person's immediate neighborhood environment

(West et al., 2010). In the present study, a quarter-mile was used to measure walking distance because in urban centers the density of and access to commercial businesses is typically greater, and residential walking distance is often shorter than a half mile (Milam et al., 2014). The proximity measure was created by calculating the network distance from each participant's home to the nearest tobacco outlet. Density and proximity measures were included as continuous variables.

#### 3.3.3c. Moderator

Gender was hypothesized to moderate the relationship between tobacco outlet exposure and tobacco use. Four interactions terms were tested: Interaction terms were created between gender and TO outlet density, gender and TA outlet density, gender and proximity to the nearest TO outlet, and gender and proximity to the nearest TA outlet.

#### 3.3.3d. Control Variables

Using binary variables, the adjusted models controlled for financial strain (i.e., having at least enough money to meet needs), education (i.e., at least a high school diploma or GED), history of tobacco use (i.e., having ever used tobacco prior to the year of interview), association with friends who smoke cigarettes, past month alcohol use, and past month marijuana use. Baseline intervention status was controlled for using a categorical variable representing participants who were randomly assigned to the classroom centered intervention, the family school partnership, and the control group (i.e., standard classroom setting). A separate category was created for the seven participants (three females and four males) with no intervention information at baseline. The control group was the reference category.

#### 3.3.4. Spatial Analysis

Tobacco outlet and alcohol outlet locations were geocoded using ArcGIS v.10.1 (ESRI, 2012). Geocoding is the process used to assign a spatial location to an address record (Waller & Gotway, 2004). Each BPP participant home address record was already assigned a latitude and longitude value, so the geocoding of participants' home addresses was not necessary. Quarter-mile network buffers (i.e., walking distance) were added around each participant's home using the Network Analysis Extension Service Area tool in ArcGIS, which accounts for navigating street networks, as compared to straight-line distance, which ignore street networks. The count of tobacco outlets per quarter-mile was determined using the spatial joining tool in ArcGIS. Spatial joining is a process used to combine multiple map layers (e.g., geocoded tobacco outlet files and buffered distance information) into one data set (Waller & Gotway, 2004). To create the density measure the count of outlets per quarter-mile was divided by the area of each network buffer. In addition, proximity to the nearest tobacco outlet from each participant's home was determined using the Network Analyst Extension feature in ArcMap.

### 3.3.5. Statistical Analysis

Logistic regression models via GEE were used to estimate odds ratios to express the strength of association between tobacco outlet density and past month tobacco use, as well as the strength of association between proximity to nearest tobacco outlet and past month tobacco use. Generalized Estimating Equations were used to account for potential clustering of the outcome by census tract, by providing robust standard errors (Vittinghoff, Glidden, Shiboski, & McCulloch, 2005a; Zeger & Liang, 1986). All data were analyzed using Stata/SE statistical software version 13 (Stata, 2013).

### **3.4. Results**

#### **3.4.1. Sample description**

Among this sample, 17.6% (n=51) of participants used tobacco within the past month. Past month tobacco use was not significantly associated with intervention group ( $\chi^2 = 0.95$ ,  $df = 3$ ,  $p = 0.75$ ) in the pooled sample. Participants ranged in age from 21.2 to 23.6 years old (mean = 22.2 years; standard deviation [SD] = 0.41 years).

Approximately half of the participants were male (51.3%). The majority of the participants had at least a high school diploma or GED (84.1%), less than enough money to meet their needs (57.2%), no history of tobacco use (52.4%), had no friends who smoked cigarettes (60.7%), and most participants did not use alcohol (66.6%) or marijuana (87.6%) in the past month. On average, participants lived within 552 meters (SD = 459 meters) of a TO outlet, and within 658 meters (SD = 500 meters) of a TA outlet. The average density per quarter mile was 16.4 (SD = 26.4) for retail outlets that sold tobacco only, and 7 outlets per quarter mile (SD = 11.3) for outlets that sold both tobacco and alcohol. Sample characteristics according to past month tobacco use are reported in Table 3.1.

#### **3.4.2. Density of tobacco only (TO) outlets**

Density of TO outlets was not significantly associated with past month tobacco use in the pooled unadjusted model (OR = 1.01,  $p = 0.13$ ) or after adjusting for confounders (i.e., gender, financial strain, education, history of tobacco use, association with friends who smoke cigarettes, past month alcohol use, and past month marijuana use, and baseline intervention status (adjusted OR [aOR] = 1.00,  $p = 0.60$ ). However, the significant association was masked by gender. An interaction was tested between gender



and TO outlet density, and gender significantly modified the relationship between tobacco outlet density and tobacco use as indicated by a significant interaction term (aOR = 1.03,  $p < 0.01$ ) between gender and TO outlet density within a quarter mile of participants' homes, controlling for history of tobacco use, association with friends who smoke cigarettes, past month marijuana use, past month alcohol use, education status, financial strain, and baseline intervention status. Results were therefore stratified by gender (Model 1) and reported in Table 3.2 for women and Table 3.3 for men. Density of TO outlets was significant for women (aOR = 1.02,  $p < 0.05$ ), but not men (aOR = 0.98,  $p > 0.11$ ). Furthermore, the association of the baseline intervention with past month tobacco use differed by gender. Among men the baseline intervention status was associated with past month tobacco use, such that the classroom centered intervention was significantly associated with a lower odds of past month tobacco use relative to the control group (aOR = 0.24;  $p < 0.05$ ). Among women ( $n=138$ ), intervention status at baseline was not significantly associated with tobacco use, thus was not included in the final model ( $n=141$ ). In the adjusted, stratified model for women, which included intervention status, the participants ( $n = 3$ ) with no intervention status at baseline were drop due to multi-collinearity, which explains the difference in sample size from the final model in Table 3.2 that did not include intervention status ( $n = 141$ ) and the model that did include intervention status ( $n=138$ ).

#### 3.4.3. Density of tobacco and alcohol (TA) outlets

The relationship between TA outlet density and past month tobacco use was not significant in the pooled models (OR = 1.01,  $p = 0.69$ ; aOR = 0.99,  $p > 0.90$ ). However, there was a significant interaction between TA outlet density and gender, as indicated by

a significant interaction term ( $aOR = 1.07, p < 0.05$ ), thus results were stratified by gender (Model 2) and reported in Table 3.2 for women and Table 3.3 for men. TA outlet density was significantly associated with past month tobacco use for women only in the unadjusted model ( $OR = 1.04, p < 0.05$ ). This association was attenuated after adjusting for confounders ( $aOR = 1.04, p = 0.12$ ) (Table 3.2). Among men TA outlet density was not associated with past month tobacco use. Additionally, among men, the baseline classroom centered intervention relative to the control group was significantly associated with a lower odds of past month tobacco use ( $aOR = 0.26; p < 0.05$ ) (Table 3.3). Among women ( $n=138$ ), intervention status at baseline was not significantly associated with tobacco use, and thus not included in the final model ( $n=141$ ).

#### 3.4.4. Proximity to the nearest TO outlet

Proximity to the nearest TO outlet was not significantly associated with past month tobacco use in the unadjusted ( $OR = 1.00, p = 0.39$ ) or adjusted ( $aOR = 1.00, p = 0.97$ ) pooled analyses controlling for gender, financial strain, education, history of tobacco use, association with friends who smoke cigarettes, past month alcohol use, and past month marijuana use, and baseline intervention status. There was marginal evidence that gender modified the relationship between proximity to the nearest TO outlet and past month tobacco use, as the odds ratio for the interaction term between gender and proximity was significant ( $aOR = 0.99, p < 0.05$ ). However, when stratified by gender, distance to the nearest TO outlet was not significantly associated with tobacco use for either women ( $OR = 1.00, p = 0.25; aOR = 1.00, p = 0.18$ ) or men ( $OR = 1.00, p = 0.99; aOR = 1.00, p = 0.14$ ). Additionally, baseline intervention status was not significantly associated with past month tobacco use in either the pooled or stratified models.

#### 3.4.5. Proximity to TA outlet

Proximity to the nearest TA outlet was not significantly associated with past month tobacco use in the unadjusted (OR= 1.00,  $p = 0.93$ ) or adjusted pooled analyses (aOR =1.00,  $p = 0.94$ ). There was marginal evidence that gender modified the relationship between proximity to the nearest TA outlet and past month tobacco use, as the odds ratio for the interaction term between gender and proximity was significant (aOR = 0.99,  $p < 0.05$ ). However, when stratified by gender, distance to the nearest TA outlet was not significantly associated with tobacco use for either women (OR= 1.00,  $p = 0.30$ ; aOR = 1.00,  $p = 0.17$ ) or men (OR = 1.00,  $p = 0.40$ ; aOR = 1.00,  $p > 0.18$ ). Intervention status was however associated with past month tobacco use among men, such that men in the classroom centered intervention relative to the control group had a 73% lower odds of past month tobacco use (aOR= 0.27,  $p < 0.05$ ). Intervention status was not significantly associated with past month tobacco use among women ( $n=138$ ).

### **3.5. Discussion**

#### 3.5.1. Summary

This study aimed to assess gender differences in the relationship between tobacco outlet exposure (i.e., density and proximity) at the neighborhood level (i.e., within a quarter-mile of participants' homes) and past month tobacco use among African American young adults living in Baltimore City in 2009. Tobacco outlets were categorized based on whether or not they were licensed to sell tobacco only (TO), or tobacco and alcohol (TA). There were four central findings: 1. Gender moderated the relationship between TO outlet density and tobacco use, as well as TA outlet density and tobacco use, such that these associations were positive and significant only among

women 2. The strength and significance of the association between tobacco outlet density and tobacco use varied depending on whether or not the outlet was licensed to sell tobacco only or tobacco and alcohol. 3. Proximity to the nearest tobacco outlet was not associated with past month tobacco use. 4. The baseline intervention administered to participants in 1993, when they were in the first grade, was associated with reduced odds of tobacco use among men.

### 3.5.2. Tobacco outlet density

There is a limited literature base examining the association between tobacco outlet exposure and tobacco use. Of the existing studies, most focus on school-aged youth (Adachi-Mejia et al., 2012; Henriksen et al., 2008; Johns et al., 2013; Lipperman-Kreda et al., 2012b; Lipperman-Kreda et al., 2013; McCarthy et al., 2009; Pokorny et al., 2003; West et al., 2010). Considering social constraints that may discourage tobacco use differ for youth versus young adults – with regard to legal age to purchase tobacco products for example, as well as supervision from authority figures such as school teachers and principles – it is important to understand the burden of tobacco outlet exposure on tobacco use among young adults. Of the six studies that included adults in their samples, four found a positive association between tobacco outlet density and tobacco use (Chuang et al., 2005; Li et al., 2009; Novak et al., 2006; Reid et al., 2005). The current study's results are consistent with these findings. However three of the four studies did not focus on exposure to tobacco outlets at the neighborhood level (Li et al., 2009; Novak et al., 2006; Reid et al., 2005). Of the remaining two studies, one study found that tobacco outlet density was not significantly associated with smoking behaviors (i.e., cessation) (Reitzel et al., 2011), and the relationship between density and tobacco use was not

measured in the other study (Paul et al., 2010). Neither of these six studies focused on gender differences among African American young adults (i.e., 18-25 years old).

### 3.5.3. TO versus TA outlets

The current study also assessed the independent association between past month tobacco use and retail outlets licensed to sell both tobacco and alcohol (TA) versus those licensed to sell tobacco only (TO). This is important because the influence of an outlet licensed to sell alcohol and tobacco (i.e., TA outlet) on tobacco use may vary relative to outlets licensed to sell tobacco only. In the current study, among women there was a significant association between TO outlets and past month tobacco use, as well as between TA outlet density and past month tobacco use. However, the significant association between TA outlet density and tobacco use was attenuated after adjustment for confounding (i.e., financial strain, education, history of tobacco use, association with friends who smoke cigarettes, past month alcohol use, and past month marijuana use). When TA and TO outlets were included in the same model, the significant association between TO outlet density and tobacco use among women was masked, which suggest that combining the outlets can potentially be a form of misclassification that can lead to biased results. For example, in a sensitivity analysis (using the same control variables used in the main analyses) when tobacco outlet density was calculated using all 1133 outlets (i.e., 777 TO outlets plus 356 TA outlets), the relationship between tobacco outlet density in the pooled sampled (n=290) remained insignificant (OR= 1.01, p = 0.22; aOR = 1.00, p = 0.71), and the interaction term between gender and tobacco outlet density was significant (aOR = 1.03, p = 0.001), indicative of gender differences. When stratified by gender, tobacco outlet density was not significantly associated with past month tobacco

use for men (OR= 1.00,  $p = 0.56$ ; aOR= 0.98,  $p = 0.08$ ). Among women, in the unadjusted sensitivity analysis, tobacco outlet density was positively and significantly associated with past month tobacco use (OR= 1.02,  $p < 0.01$ ), however, this relationship was diminished in the adjusted model (OR= 1.01,  $p = 0.09$ ), and the significant relationship between TO outlet density and tobacco use noted in the main analyses was masked.

Outlets that sell both tobacco and alcohol (i.e., TA outlets) can be considered either a tobacco outlet or an alcohol outlet from a research perspective. However, from a policy perspective, TA outlets are subject to zoning and density regulations pertaining to alcohol outlets. For example, the rules and regulations of the Baltimore City liquor Board established a maximum alcohol outlet density of 1 outlet per 1,000 residents, and zoning laws prohibit the establishment of new off-premise alcohol outlets in residential areas (Thornton et al., 2013). Therefore, alcohol outlets that also sell tobacco (i.e., TA outlets) are subject to the zoning and density restrictions related to alcohol retail, whereas TO outlets are not subject to these regulations. This helps explain why density was higher on average for TO outlets relative to TA outlets, and why the proximity of TA outlets to participants' homes was on average greater than that of TO outlets, which in turn lends insight into why the strength of association and statistical significance between tobacco outlet density and tobacco use varied based on whether or not outlets sold tobacco only, or tobacco and alcohol. Furthermore, the results from the current study are consistent with prior research asserting that alcohol outlets are not significantly associated with tobacco use. For example, in a study assessing the relationship between alcohol outlet exposure and tobacco, alcohol, and marijuana use when this cohort was one year post

high-school, the count of alcohol outlets within a quarter mile was not significantly associated with tobacco use (Milam et al., 2014). It is likely that some of the alcohol outlets in the study by Milam and colleagues were also licensed to sell tobacco (i.e., TA outlets). However, the current study is the first to assess potential differences in the association between TO and TA outlets on tobacco use. Additional research is needed to corroborate these findings, as well as to explore whether or not mechanisms driving the association between TA outlet exposure and TO outlet exposure and tobacco use differ.

#### 3.5.4. Proximity to the nearest outlet

Of the three adult studies that measured the association between proximity to the nearest tobacco outlet and tobacco use, two found an inverse relationship (Chuang et al., 2005; Reitzel et al., 2011), and one study found that approximately 30% of participant people reported that they would attempt to quit smoking or cut down if there were no place to buy tobacco within walking distance (Paul et al., 2010). In the current study, proximity to tobacco outlets was not significantly associated with tobacco use.

Considering the limited amount research examining this relationship among young adults, more research is needed to corroborate these findings. In a sensitivity analysis pooling all 1133 tobacco outlets, there was still no statistically significant association between living within close proximity to tobacco outlets and past month (n=290) (OR 1.00,  $p = 0.50$ ; aOR = 1.00,  $p = 0.99$ ). There was marginal evidence of gender differences as indicated by a significant interaction term between gender and proximity (aOR = 0.99,  $p < 0.05$ ). When stratified by gender, result were not statistically significant for women (OR 1.00,  $p = 0.38$ ; aOR = 1.00,  $p = 0.26$ ) or men (OR 1.00,  $p = 0.92$ ; aOR = 1.00,  $p = 0.18$ ).

### 3.5.5. Intervention Status

Participants in this cross-sectional study were drawn from a larger randomized controlled trial, which evaluated a classroom-centered (CC) intervention, and a family-school partnership (FSP) aimed at improving academic success, reducing concentration problems, and reducing aggressive and shy behaviors (Ialongo et al., 1999). The interventions were administered when participants were in the first grade, and substance abuse prevention was among the distal targets of the interventions (Ialongo et al., 1999). The interventions were designed to reduce early risk behaviors of substance use and abuse, affective disorder, and conduct disorder. The FSP aimed to reduce these behaviors by focusing on communication between the family and school, and parenting practices associated with child learning and behavior, whereas the CC intervention targeted teacher classroom behavioral management practices, and instructional practices (Ialongo et al., 1999). The control condition was the standard classroom setting (Ialongo et al., 1999). Consistent with previous literature assessing the association of the intervention with tobacco use (Storr et al., 2002; Wang et al., 2009), the current study found that the CC intervention relative to the standard classroom setting was more successful in reducing tobacco use. Even though the FSP was not significantly associated with tobacco use in this study, and the CC intervention was only significant at reducing the odds of tobacco use among men, it is remarkable that exposure to a single year of preventive intervention in the first grade would be associated with reduced tobacco use four years post high school.



#### 3.5.6. Limitations

Study findings must be interpreted in light of important limitations. First, the cross-sectional design does not lend to causal inference with regard to temporality of exposure and outcome. Additionally, all participants were African American, young adults, living in the inner-city, thus inferences may not be generalizable to other populations. Additionally, tobacco, and other drug use were assessed via self-report, thus there was the potential for recall bias in the reported use of these substances. Given the high density of tobacco outlets in Baltimore City, these results may not be generalizable to rural areas or geographic locations where tobacco outlet density is lower.

#### 3.5.7. Strengths

The limitations of this study should not over shadow the strengths. First, this study assessed the association of tobacco outlet exposure and tobacco use among a high-risk population. This is important because there are only a few studies assessing the relationship between tobacco outlet exposure and tobacco use, and none focus exclusively on inner-city, African American, young adults. Additionally, this study elucidates the moderating role of gender on environmental cues to smoke, which may be important to practitioners aiming to develop environmentally based interventions to reduce tobacco use among this population. Furthermore, tobacco outlets were classified based on whether or not they were licensed to sell tobacco only or tobacco and alcohol. Classifying these outlets separately provides insight into the independent association each type of outlet has on tobacco use. Lastly, this study highlights the importance of early preventive intervention in the primary school years. Efforts to reduce tobacco outlet density, and thus the risk of tobacco use attributable to tobacco outlet density, may be

arduous, thus capitalizing on other means to reduce tobacco use, such as early prevention, can lend to a multi-tiered approach to reduce tobacco use among high-risk populations.

### **3.6. Conclusion**

Tobacco outlet density is a malleable environmental correlate of tobacco use, and high outlet density in vulnerable communities undermines public health efforts to reduce tobacco use and health disparities among marginalized groups. Policy makers and public health advocates should act with urgency to reduce tobacco outlets in residential areas in order to afford people the opportunity for healthier, tobacco free lives where they live.

Table 3.1. Sample characteristics by past month tobacco use in 2009 (N=290)

	Tobacco use within the past month			Total, n (%)
	Yes (n=51)	No (n=239)	p-value	
<b>Age – years</b>				290 (100)
Mean (SE)	22.3 (0.05)	22.2 (0.03)	0.71 <sup>+</sup>	[Mean=22.2; SE=0.02]
<b>Gender – no. (%)</b>			0.14	
Female	20 (14.2)	121 (85.8)		141 (100)
Male	31 (20.8)	118 (79.2)		149 (100)
<b>Income – no. (%)</b>			<0.05	
Able to meet needs	15 (12.1)	109(87.9)		124 (100)
Unable to meet needs	36 (21.7)	130(78.3)		166 (100)
<b>Education– no. (%)</b>			<0.001	
≥HS Diploma/GED	33 (13.5)	211 (86.5)		244 (100)
<HS Diploma/GED	18 (39.1)	28(60.9)		46 (100)
<b>Hx Tobacco Use – no. (%)</b>			<0.001	
Yes	44 (31.9)	94 (68.1)		138 (100)
No	7 ( 4.6)	145 (95.4)		152 (100)
<b>Friends Smoke– no. (%)</b>			<0.001	
Yes	36 (31.6)	78 (68.4)		114 (100)
No	15 ( 8.5)	161 (91.5)		176 (100)
<b>Alcohol use – no. (%)</b>			<0.001	
Yes	28 (28.9)	69 (71.1)		97 (100)
No	23 (11.9)	170 (88.1)		193 (100)
<b>Marijuana use – no. (%)</b>			<0.001	
Yes	19 (52.8)	17 (47.2)		36 (100)
No	32 (12.6)	222 (87.4)		254 (100)
<b>Intervention</b>			0.75 <sup>*</sup>	
Classroom	18 (18.4)	80 (81.6)		98 (100)
Family	16 (18.2)	72 (81.8)		88 (100)
No baseline	2 (28.6)	5 (71.4)		7 (100)
Control	15 (15.5)	82 (84.5)		97 (100)
<b>Proximity</b>				
Tobacco Only				290 (100)
Mean (SE)	495 (57.0)	564 (30.0)	0.33	[Mean=551.7; SE= 26.9]
Tobacco/Alcohol				290 (100)
Mean (SE)	652 (68.7)	659 (32.5)	0.92	[Mean=657.7; SE= 29.4]

**Density**

Tobacco only Mean(SE)	22.7 (4.9)	15.1 (1.5)	0.14	290 (100.0) [Mean=16.4; SE= 1.5]
Tobacco/Alcohol Mean(SE)	7.7 (1.8)	6.9 (0.7)	0.64	290 (100) [Mean=7.0; SE= 0.7]

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P-values based on chi-squared test unless otherwise noted

+ Student's t-test

\* Fisher's exact test

SE = Standard Error

HS = High school

Hx= History

Tobacco only indicates that the retail outlets held a license to sell cigarettes, but not alcohol

Tobacco/Alcohol indicates that the retail outlets held a license to sell cigarettes and alcohol

Density calculated per  $\frac{1}{4}$  mile

GED = General Education Development (high school equivalency credentials)

Table 3.2. Odds ratios and 95% confidence intervals (CIs) of the association between past month tobacco use and tobacco outlet density among young adult African American females living in Baltimore City, Maryland in 2009 (n= 141)

	uOR	aOR <sup>1</sup> (Model 1)	aOR <sup>2</sup> (Model 2)
Income	0.43 (0.16-1.18)	0.43 (0.13-1.45)	0.42 (0.99-1.10)
Education	0.24 (0.07-0.81)*	0.27 (0.07-0.97)*	0.26 (0.07-0.98)*
Hx Tobacco Use	9.33 (2.80-31.15) <sup>+</sup>	5.00 (1.53-16.36)**	5.11 (1.65-15.83)**
Friends Smoke	5.70 (1.92-16.87)**	3.29 (0.91-11.88)	3.77 (1.08-13.18)*
Alcohol use	3.61 (1.23-10.62)*	3.49 (1.21-10.03)*	3.48 (1.10-10.95)*
Marijuana use	3.54 (1.01-12.40)*	0.94 (0.20-4.48)	0.80 (0.14-4.70)
Density: Tobacco	1.02 (1.01-1.03)**	1.02 (1.00-1.03)*	---
Density: Tobacco/Alcohol	1.04 (1.00-1.07)*	---	1.04 (0.99-1.10)

- uOR: Unadjusted odds ratio; aOR: Adjusted odds ratio; CI: Conference Interval
- aOR<sup>1</sup>/Model 1: The adjusted odds ratio for model 1, which assesses the relationship between past month tobacco use and density of retail outlets licensed to sell tobacco only within ¼ mile of participants' homes; adjusted for all variables in the table
- aOR<sup>2</sup>/Model 2: The adjusted odds ratio for model 2, which assesses the relationship between past month tobacco use and density of retail outlets licensed to sell both tobacco and alcohol within ¼ mile of participants' homes; adjusted for all variables in the table
- \* p-value < 0.05; \*\* p-value ≤ 0.01; + p-value ≤ 0.001
- Hx = history
- Unrounded 95% CI relating density to past month tobacco use, model 1:  
aOR 1.02 (95% CI: 1.001117, 1.032137); p-value =0.03
- Unrounded 95% CI relating density to past month tobacco use, model 2:  
uOR 1.04 (1.000739, 1.072463); p-value = 0.04

Table 3.3. Odds ratios and 95% confidence intervals (CIs) of the association between past month tobacco use and tobacco outlet density among young adult African American males living in Baltimore City, Maryland in 2009 (n= 149)

	uOR	aOR <sup>1</sup> (Model 1)	aOR <sup>2</sup> (Model 2)
Income	0.57 (0.19-1.67)	1.21 (0.35-4.19)	1.21 (0.34-4.26)
Education	0.24 (0.11-0.55) <sup>+</sup>	0.32 (0.09-1.12)	0.38 (0.11-1.24)
Hx Tobacco Use	10.21 (2.72-38.35) <sup>+</sup>	7.16 (1.46-35.22) <sup>*</sup>	6.76 (1.38-33.05) <sup>*</sup>
Friends Smoke	4.83 (2.33-10.03) <sup>+</sup>	2.39 (0.73-7.81)	2.04 (0.71-5.86)
Alcohol use	3.17 (1.31-7.66) <sup>**</sup>	1.43 (0.51-4.02)	1.50 (0.50-4.53)
Marijuana use	12.34 (4.44-34.31) <sup>+</sup>	14.78 (4.37-49.94) <sup>+</sup>	10.63 (3.01-37.54) <sup>+</sup>
Density: Tobacco	1.00 (0.98-1.01)	0.98 (0.95-1.00)	---
Density: Tobacco/Alcohol	0.98 (0.94-1.02)	---	0.97 (0.93-1.01)
Intervention			
Control	ref	ref	ref
Classroom	0.83 (0.33-2.09)	0.24 (0.07-0.89) <sup>*</sup>	0.26 (0.08-0.84) <sup>*</sup>
Family	1.15 (0.41-3.25)	0.32 (0.06-1.78)	0.44 (0.11-1.78)
No design information	3.96 (0.34-45.77)	1.43 (0.13-15.71)	1.64 (0.14-18.95)

- uOR: Unadjusted odds ratio; aOR: Adjusted odds ratio; CI: Conference Interval
- aOR<sup>1</sup>/Model 1: The adjusted odds ratio for model 1, which assesses the relationship between past month tobacco use, and density of retail outlets licensed to sell tobacco only within ¼ mile of participants' homes; adjusted for all variables in the table
- aOR<sup>2</sup>/Model 2, The adjusted odds ratio for model 2, which assesses the relationship between past month tobacco use, and density of retail outlets licensed to sell both tobacco and alcohol within ¼ mile of participants' homes; adjusted for all variables in the table
- \* p-value < 0.05; \*\* p-value ≤ 0.01; + p-value ≤ 0.001
- Hx = history
- Ref = reference group

**Chapter 4:** The mediating role of perceived harmfulness and disapproval of cigarette use  
in the relationship between tobacco outlet exposure and tobacco use among African  
American young adults

**4.1. Abstract**

Introduction: Mechanisms that explain the relationship between tobacco outlet exposure and tobacco use are understudied, and warrant further attention. The aim of this study is to assess the mediating role of perceived harmfulness and disapproval of cigarette use in the relationship between tobacco outlet exposure (i.e., density and proximity to outlets) and past month tobacco use among African American young adults living in Baltimore City, Maryland. Methods: This study used path analysis to evaluate the mediating role of perceived harmfulness and disapproval of cigarette use in the relationship between tobacco outlet exposure and past month tobacco use among African American young adults living in Baltimore City from 2007 through 2009. Geospatial methods were used to estimate tobacco outlet density and proximity to nearest tobacco outlet. Tobacco outlets were classified based on whether or not they were licensed to sell tobacco only (TO outlets) or tobacco and alcohol (TA outlets). Results: Disapproval of cigarette use, but not perceived harmfulness of cigarette use was a significant mediator in the relationship between tobacco outlet density and past month tobacco use, and results varied by gender. The relationship between TO and TA outlet density and past month tobacco use was fully mediated by disapproval of cigarette use among men, however disapproval of cigarette use was not a significant mediator in these relationships for women. The relationship between proximity to the nearest tobacco outlet was not mediated by either disapproval or perceived harmfulness of cigarette use for men or women. Conclusion: This study

provides a more complete picture of the relationship between tobacco outlet exposure and tobacco use by elucidating mediating factors. Results from this study has implications for policies aimed at reducing tobacco outlet density in residential areas, as well as preventive interventions aimed at addressing perceived norms about tobacco use.

## **4.2. Introduction**

Several studies show that exposure to tobacco outlets is associated with tobacco use (Henriksen et al., 2008; Johns et al., 2013; Li et al., 2009; Lipperman-Kreda et al., 2012a; Lipperman-Kreda et al., 2013; McCarthy et al., 2009; Novak et al., 2006; Pokorny et al., 2003; Reid et al., 2005; Reitzel et al., 2011; West et al., 2010). For example, greater tobacco outlet density within a mile of youths' homes was associated with greater frequency of past 30 day smoking among 13-18 year olds (Lipperman-Kreda et al., 2013). Additionally, living within close proximity to tobacco outlets was associated with smoking relapse among adults who made a quit attempt (Reitzel et al., 2011).

Considering the positive relationship between tobacco outlet density and tobacco use, and the inverse relationship between proximity to tobacco outlets and tobacco use, it follows that reducing the number of tobacco outlets within communities will subsequently reduce tobacco use. The Institute of Medicine (IOM) recommends restricting the number and location of tobacco outlets in order to promote public health around issues related to tobacco use and sales (IOM, 2007). Additionally, advocates call for a fundamental restructuring of the tobacco retail environment, with a specific focus on reducing tobacco outlet density, asserting that the ubiquitous availability of tobacco outlets, and thus tobacco products, is not consistent with public health efforts to reduce tobacco use and associated health problems (Cohen & Anglin, 2009). Enacting policies that restrict the



density and zoning of retail tobacco outlets may be the ultimate goal, however, a multi-tiered approach is needed to efficiently reduce the impact of tobacco outlet exposure on tobacco use. Specifically, mechanisms that drive this association must be identified, and all factors malleable to intervention, including reducing outlet density, must be addressed.

Most research in this area posits a direct relationship between tobacco outlet exposure and tobacco use, and evidence on the underlying mechanisms of this relationship is sparse. Exceptions include studies exploring moderating factors (Johns et al., 2013; Lipperman-Kreda et al., 2012b; Pokorny et al., 2003; Watkins et al., 2014). A variable is said to be a moderator if the strength of the direct effect of an independent variable (e.g., tobacco outlet density) on a dependent variable (e.g., smoking) differs by levels of a third (moderating) variable such as gender (Geiser, 2012). Johns and colleagues (2013) found that risk taking (e.g., illicit drug use, unprotected sex) moderated the relationship between tobacco outlet exposure and smoking initiation among high-school students, such that low risk takers relative to high-risk takers had higher odds of smoking initiation given exposure to tobacco outlets. Clean air policies also moderated the relationship between tobacco outlet density and smoking behaviors. The positive association between tobacco outlet density and smoking was strongest in communities with minimal clean air policies relative to communities with strong clean air policies (Lipperman-Kreda et al., 2012b). Additionally, among youth who did not live with an adult smoker, higher retail tobacco availability was significantly related to smoking initiation, whereas this relationship was not significant among youth with an adult smoker in the home (Pokorny et al., 2003). Furthermore, in a study among smokers who made a quit attempt, distance from home was a moderator in the relationship between

tobacco outlet exposure and cravings to smoke, such that closer proximity to tobacco outlets was associated with stronger cravings to smoke when participants were a mile or less from home, relative to more than a mile from home (Watkins et al., 2014).

To date there are no studies that assess potential mediators of the relationship between tobacco outlet exposure and tobacco use. In contrast to moderators, mediators (also known as intermediate variables) are variables in the causal pathway between an independent variable and a dependent variable. Mediators cause variation in the outcome variable and are influenced by the independent variable (Porta, 2008). Identifying mediators can help elucidate the causal pathway between tobacco outlet exposure and tobacco use, as well as lend to comprehensive preventive approaches aimed at reducing tobacco outlet density, while simultaneously addressing intermediate factors, which account for some or all of the variance between tobacco outlet exposure and tobacco use. Perceived harmfulness and approval of cigarette use are important mediators to consider in the relationship between tobacco outlet exposure and tobacco use. Social cognitive theory posits that behaviors, cognition, and the environment are inextricably linked (Bandura, 1986). Based on this theory, it is plausible that young adults may interpret the widespread availability of tobacco outlets as normative, thus approving of tobacco use and underestimating the risk associated with smoking. Therefore, perceived harmfulness and disapproval of cigarette use may partially or fully mediate the association between tobacco outlet exposure and tobacco use. In a study assessing perceived harmfulness of substances (e.g., heroin, marijuana, alcohol, tobacco) participants rated cigarettes, chewable tobacco, and beer among the least harmful (Sarkar, Balachander, & Basu, 2014). Additionally, up to 56% of inner-city African American young adults not in

school and unemployed were unaware of the harmfulness of different types of tobacco product (i.e., cigarettes and little cigars) (Milam et al., 2013). Similar misconceptions about the harmfulness of tobacco products were noted among a sample of racially diverse college freshman (Smith, Curbow, & Stillman, 2007). Furthermore, perceived harmfulness is inversely related to tobacco and other drug use (Heinz et al., 2013; Sterling, Berg, Thomas, Glantz, & Ahluwalia, 2013; Thornton, Baker, Johnson, & Lewin, 2013). Moreover, approval of and from peers regarding tobacco use is associated with tobacco use behaviors (Heinz et al., 2013; Johns et al., 2013; Kulbok et al., 2008; Trucco, Colder, Bowker, & Wieczorek, 2011; Tucker, Martinez, Ellickson, & Edelen, 2008; Zehe, Colder, Read, Wieczorek, & Lengua, 2013). For example, among a sample of ethnically diverse college student, participants reporting life time hookah use (i.e., water-pipe tobacco smoking) as compared to those that did not use, had a higher number of friends who approved of this form of tobacco use (Heinz et al., 2013). Perceptions that friends approved rather than disapproved of smoking was significantly associated with a higher odds of smoking initiation among ninth through 12<sup>th</sup> graders attending a inner-city high school (Johns et al., 2013). Furthermore, approval of abstaining from smoking from peers, parents, and support networks (e.g., church members, and teachers) was associated with youth 16 to 17 years old choosing not to smoke (Kulbok et al., 2008), while pro-smoking peer and family influences were associated with future smoking, and intentions to smoke among youth and young adults (Trucco et al., 2011; Tucker et al., 2008). Furthermore, Zehe and colleagues (2013) found that perceived peer approval of tobacco use moderated the relationship between anxiety and tobacco use among adolescent girls. It is clear that perceived harmfulness and dis/approval of tobacco use are important

factors related to tobacco use behaviors, and this study aims to elucidate the mediating role of perceived harmfulness and disapproval of cigarettes use in the relationship between tobacco outlet exposure (i.e., density and proximity) and past month tobacco use. It is hypothesized that perceived harmfulness and disapproval of tobacco use will mediate the relationship between tobacco outlet exposure and tobacco use, and results will vary by gender such that perceived harmfulness and disapproval of cigarettes use will fully mediate the relationship for women, and partially mediate the relationship for men. This hypothesis is supported by previous research on this cohort that found that perceptions of neighborhood disorder (e.g., drug activity) was associated with tobacco and other drug use (Brown et al., 2014; Lambert et al., 2004), and that perceived harmfulness and disapproval of substances mediated this relationship when participants were in the seventh through ninth grades (Lambert et al., 2004). Additionally, results varied by gender when participants were adolescents (Lambert et al., 2004) and during young adulthood (Brown et al., 2014) such that the association between perceived neighborhood drug activity and tobacco use was positive and significant only among women, and did not reach significance for men when this cohort was one year post high-school (Brown et al., 2014). Also, perceived harmfulness and disapproval of substances fully mediated the relationship between perceptions of neighborhood disorder and tobacco and other drug use among females, and partial mediated this relationship for males when participants were in the seventh through ninth grades (Lambert et al., 2004). The current study extends prior research by Lambert and colleagues (2004) and Brown and colleagues (2014) by evaluating an important environmental correlate of tobacco use that was not assessed in either study – tobacco outlets. This is important in order to gain a

more complete understanding of the influence of different environmental correlates on tobacco use. When this cohort was one year post high-school, perceived neighborhood drug activity was one of three environmental correlates assessed in relation to tobacco use, and was the only one that yielded significance, whereas perceived neighborhood social cohesion, and systematic social observation of neighborhood disorder by trained field raters were not significantly associated with tobacco use (Brown et al., 2014). Tobacco outlet exposure is an environmental correlate of tobacco use that warrants further attention, specifically with regard to understanding mediating factors of this relationship. Figure 4.1 provides the conceptual framework for this study.

### **4.3. Methods**

#### **4.3.1. Participants**

Participants (n= 230) in the current study were African American young adults residing in Baltimore City, Maryland from 2007 to 2009. The analytic sample was derived from a larger cohort of 799 students who participated in the Johns Hopkins Second Generation Baltimore Prevention Program (BPP) intervention in the first grade in 1993. The BPP is a field trial of two universal first grade interventions and respondents were followed through adulthood (Ialongo et al., 1999). Inclusion criteria for the current study were limited to African American participants who lived in Baltimore City, because tobacco outlet data was only available for City residents. Additionally, 94% of the participants living in Baltimore City in 2007 and thus eligible for the current study were African American, limiting the ability to detect differences by race. A total of 591 participants completed the BPP interview in 2007, and 256 lived in Baltimore City – 241 (94%) were African American, and 15 were white (6%). Of the 241 participants who met

inclusion criteria, 4.6% (n=11) were missing on either the mediators, the distal outcome (past month tobacco use), or a covariate of interest and were excluded from the main analyses (i.e., path analysis) of the study. The path analyses were estimated in Mplus using the weighted least squares mean and variance (WLSMV) estimator. The WLSMV is a robust estimator, which maximizes use of all information, by allowing missingness to be a function of the observed covariates, but not the observed outcomes (Muthén & Muthén, 1998-2012), such that participants were only excluded if they were missing on all dependent variables (6 males, and 4 females), or on exogenous variables, but not dependent variables (1 male). Of the 591 participants interviewed in 2007, those included in the analytic sample (n = 230) did not differ significantly from those excluded (n = 361) with respect to baseline intervention status, ability to meet financial needs, education, past month alcohol use, past month marijuana use, past month tobacco use, history of tobacco use, affiliation with friends who smoke cigarettes, age, or gender. Participants did however differ by perceived harmfulness and disapproval of cigarette use. Among participants included in the analytic sample 53.5% perceived great harm in cigarette use, relative to 41% of participants not included ( $\chi^2 = 18.7$ ,  $df = 2$ ,  $p < 0.001$ ). Additionally, 54.8% of participants in the analytic sample were more likely to strongly disapprove of cigarette use as compared to 43.8% of those not included ( $\chi^2 = 17.2$ ,  $df = 2$ ,  $p < 0.001$ ). The preference of cigarette alternatives such as little cigars (e.g., Black & Milds) among African American young adults (Jolly, 2008; Milam et al., 2013), may help explain why participants included in the study were more likely to disapprove of cigarette smoking and rate cigarette smoking as greatly harmful. Additionally, unlike cigarettes, little cigars are innocuously flavored (e.g., apple, cherry) and marketed heavily to young adults

(Jolly, 2008; Milam et al., 2013), which may influence perceived harmfulness and disapproval of cigarettes relative to other tobacco products.

#### 4.3.2. Data Sources

##### 4.3.2a. Baltimore Prevention Program (BPP) Data

In 1993, a total of 678 first grade students and their families, representative of the number of students entering first grade in nine public elementary schools in Baltimore City, were recruited to participate in the BPP trial to evaluate two first grade preventive interventions – a classroom-centered (CC) intervention, and family-school partnership (FSP) interventions – aimed at improving academic success, reducing concentration problems, and reducing aggressive and shy behaviors (Ialongo et al., 1999). The proximal targets of both the FSP and the CC interventions were to prevent poor academic achievement, reduce concentration problems, and reduce aggressive and shy behaviors – known early risk factors for later substance use disorders (Ialongo et al., 1999). The distal targets of these interventions were to prevent risk of substance abuse, depression, and antisocial behavior (Ialongo et al., 1999). Three classrooms from each of the nine schools were randomized to either of the two interventions arms or the control arm (standard classroom setting) of the trial (Ialongo et al., 1999). An additional 121 participants transferred into the participating schools after the baseline assessments, for a total sample size of 799. A description of the original study sample is reported in previous research (Ialongo et al., 1999). Annual assessment of tobacco and other drug use for this cohort started in the sixth grade (Wang et al., 2009; Wang et al., 2012). The Institutional Review Board at The Johns Hopkins Bloomberg School of Public Health approved this study.

#### 4.3.2b. Tobacco Outlet Data

Data on 1,535 retail establishments licensed to sell cigarettes (e.g., smoke shops, corner stores, grocery stores) in Baltimore City in 2007 were obtained from the Circuit Court for Baltimore City, Land Records and License Division office. Retail establishments for this analysis were classified based on whether or not they were licensed to sell both tobacco and alcohol (TA), or licensed to sell tobacco only (TO). Duplicate address locations (n=97) were removed based on latitude and longitude. The remaining 1,438 outlets were analyzed in this study. There were 955 outlets licensed to sell tobacco only, and 483 licensed to sell both tobacco and alcohol. The TO and TA outlets were analyzed in separate models.

#### 4.3.2c. Alcohol Outlet Data

Alcohol outlets were included in this study for the purpose of identifying outlets that were licensed to sell both tobacco and alcohol (n=483). The number of establishments licensed to sell alcohol in Baltimore City in 2007 (n=1,328) was obtained from the Board of Liquor License Commissioners for Baltimore City. Duplicate address locations (n=51) were removed based on latitude and longitude. The remaining 1,277 outlets were analyzed in this study. There were 483 sets of latitude and longitude coordinates that appeared in both the tobacco outlet data and the alcohol outlet data, and these 483 locations were classified as TA outlets.



#### 4.3.3. Measures

##### 4.3.3a. Outcome

Current tobacco use in 2009 was the outcome of interest. Participants who reported having used tobacco within the past month were considered current users. The BPP assessment measures recency of tobacco use using questions from the Monitoring the Future Nation Survey (Johnston et al., 1995) which asked participants whether or not they used tobacco within the last week, month, year, or over a year ago. Audio computer-assisted self-interview (ACASI) methods were used to assess tobacco use to promote privacy, and to obtain accurate and complete responses (Storr et al., 2002). Using a binary variable, tobacco use anytime within the past month was coded 1, otherwise 0.

##### 4.3.3b. Exposures

Exposures of interest – tobacco outlets density and proximity to the nearest tobacco outlet – were assessed in 2007. The density measures were created by dividing the count of tobacco outlets within a quarter mile of participants' homes by the area of each quarter mile network buffer. Studies examining exposure to tobacco outlets, typically estimate walking distance between a quarter mile and one mile (Henriksen et al., 2008; Lipperman-Kreda et al., 2013; McCarthy et al., 2009; West et al., 2010). Currently, there is no gold standard to define a buffer size representative of a person's immediate neighborhood environment (West et al., 2010). In the current study, a quarter-mile was used to measure walking distance because in urban centers the density of and access to commercial businesses is typically greater, and residential walking distance is often shorter than a half mile (Milam et al., 2014). The proximity measure for this study was created by calculating the network distance from each participant's home to the

nearest tobacco outlet. Density and proximity were dichotomized via a median split, such that values at or above the median for either measure were coded as 1, and values below the median were coded 0. The median TA outlet density per quarter mile was 0, so values above 0 were coded as 1, and values equal to zero were the reference group. Previous research examining tobacco and alcohol outlet exposure categorized exposure measures in order to compare outcomes (e.g., drug use, and opportunity for drug use) among those living at the lowest levels of exposure to those living at the highest levels of exposure (Henriksen et al., 2008; Johns et al., 2013; Milam, Furr-Holden, Cooley-Strickland, Bradshaw, & Leaf, 2013). Furthermore, categorizing tobacco outlet exposure (e.g., median split) may lend to practical recommendations regarding reducing tobacco outlet density, especially in areas where outlet density is greatest (Ahern, Margerison-Zilko, Hubbard, & Galea, 2013).

#### 4.3.3c. Mediators

Perceived harmfulness and disapproval of cigarette use were evaluated as mediators, and assessed in 2008. The BPP began annual assessment of perceived harmfulness and disapproval of substances when participants were in the sixth grade, using subscales from the National Survey of Drug Use and Health (NSDUH), and Monitoring the Future (MTF) National Survey. Perceptions of harmfulness were assessed using three items from the NSDUH: 1. People harm themselves when they try cigarettes once or twice? 2. People harm themselves when they use cigarettes occasionally? 3. People harm themselves when they use cigarettes regularly? Participants rated each item on a 4-point Likert Scale, with higher scores indicating greater perceived harmfulness of cigarette use (i.e., 1 = no risk; 4 = great risk). Based on previous research (Lambert et al.,

2004), a summary score was created by adding the responses to the items. The coefficient alpha for the total scale used in this study was 0.79. Perceived harmfulness was dichotomized based on a median split. The median score was 12 (i.e., great risk). Participants with a score of 12 were code 1, otherwise participants were coded 0. Disapproval of cigarette use was assessed using three items from the MTF National Survey: 1. How do you feel about kids your own age trying cigarettes once or twice? 2. How do you feel about kids your own age using cigarettes occasionally? 3. How do you feel about kids your own age using cigarettes regularly? Participants answered each item using a 3-point Likert scale, with higher scores indicating greater disapproval (i.e., 1 = would not disapprove; 3 = strongly disapprove). Based on previous research (Lambert et al., 2004), a summary score was created by adding the responses to the items. The coefficient alpha for the total scale used in this study was 0.90. Disapproval of cigarette use was dichotomized based on a median split. The median score was 9 (i.e., strongly disapprove). Participants with a score of 9 were code 1, otherwise participants were coded 0.

#### 4.3.3d. Confounders

Using binary variables, the adjusted models controlled for financial strain (1= having at least enough money to meet needs, 0= not enough money to meet needs), education (1 = at least a high school diploma or GED, 0= less than a high school education ), history of tobacco use (1= ever used tobacco, 0= never used tobacco), association with friends who smoke cigarettes (1 = at least one friend who smokes cigarettes, 0 = no friends smoke cigarettes), past month alcohol use (1= used alcohol in the past month, 0 = otherwise), past month marijuana use (1= used alcohol in the past

month, 0 = otherwise), and baseline intervention status. Dummy variables were created for the classroom centered intervention arm (1= classroom, 0 = otherwise), and family-school partnership (FSP) intervention arm (1 = FSP, 0 = otherwise). Other than the baseline intervention status, which was assessed in 1993, confounders were assessed in 2007 to avoid temporal ambiguity in the confounders' association with the mediators (assessed in 2008) and the outcome (assessed in 2009). This is an advantage over cross-sectional studies where the temporal pattern of variables cannot be surmised, thus making it difficult to determine whether or not a covariate is a mediator or a confounder. Additionally, controlling for confounding between the mediator and the outcome reduces bias in the estimation of the direct effect of the primary predictor (i.e., tobacco outlet exposure) on the distal outcome (i.e., past month tobacco use) (Vittinghoff et al., 2005a).

#### 4.3.4. Spatial Analysis

Tobacco outlet and alcohol outlet locations were geocoded using ArcGIS v.10.1 (ESRI, 2012). Geocoding is the process used to assign a spatial location to an address record (Waller & Gotway, 2004). Each BPP participant address record already had a latitude and longitude value assigned to it, so geocoding of participants' home addresses was not necessary. Quarter-mile network buffers (i.e., walking distance) were added around each participant's home using the Network Analysis Extension Service Area tool in ArcGIS, which accounts for navigating street networks, as compared to straight-line distance, which ignores street networks. The count of tobacco outlets per quarter-mile was determined using the spatial joining tool in ArcGIS. Spatial joining is a process used to combine multiple map layers (e.g., geocoded tobacco outlet files and buffered distance information) into one data set (Waller & Gotway, 2004). To create the density measure

the count of outlets per quarter mile was divided by the area of each network buffer. In addition, proximity to the nearest tobacco outlet from each participant's home was determined using the Network Analyst Extension feature in ArcMap.

#### 4.3.5. Statistical Analysis

Mediation was assessed via path analyses with probit regression. Robust standard errors were obtained via weighted least square mean variance (WLSMV) estimation. Path analysis allows for the simultaneous modeling of related regression equations – such as in the case where a variable is independent in one regression model, and dependent in another (i.e., a mediator) – making path analysis an ideal approach to assess mediation (Muthén & Muthén, 1998-2012; Zhang, Cartmill, & Ferrence, 2008). Probit regression models are used when outcomes are binary, and provide an estimate of the conditional probability of the outcome occurring (i.e.,  $Y = 1$ ), controlling for covariates (Horowitz & Savin, 2001). In a binary response model where  $F$  is the cumulative normal distribution function, the model is referred to as probit model, whereas in a logit model (an alternative approach for binary response variables), the  $F$  is the cumulative logistic distribution function. The conditional probability functions are very similar in the logit and probit models, except in the extreme tails (Horowitz & Savin, 2001). Use of probit models via path analyses are recommended when outcomes are binary and mediation is being assessed (Muthén & Muthén, 1998-2012; Zhang et al., 2008). Additionally, the WLSMV estimation, recommended when outcomes are categorical, was used. The WLSMV estimation provides robust standard errors, and maximizes use of all available data, by allowing missingness to be a function of the observed covariates (Byrne, 2012; DiStefano

& Hess, 2005; Muthén & Muthén, 1998-2012). Data were analyzed using Mplus version 7.1 (Muthén & Muthén, 1998-2012), and Stata/SE version 13 (Stata, 2013).

The mediation analyses for this study were guided by the typology of mediation and non-mediation presented by Zhao and colleagues (2010). Three patterns of mediation – complementary, competitive, and indirect-only mediation – and two patterns of non-mediation – direct only, and no-effect mediation – were presented (Zhao, Lynch Jr, & Chen, 2010). Complementary mediation is when both the direct and indirect effects are significant and point in the same direction (i.e., they have the same sign). Competitive mediation is present when the indirect and direct effects are significant and point in opposite directions. Indirect-only mediation is analogous to full mediation, and exists when there is an indirect effect, but no direct effect. Mediation is not present if a direct effect exist without an indirect effect (i.e., direct only non-mediation), or if there is neither a direct nor indirect effect (i.e., no-effect non-mediation) (Zhao et al., 2010). To establish mediation, Zhao and colleagues (2010) posit that only one test is needed, which is the bootstrap test of the indirect effect. Bootstrapping is a method that estimates the sampling distribution of a statistic through repeated resampling (with replacement) of the observed data (Vittinghoff, Glidden, Shiboski, & McCulloch, 2005b). If the bootstrapped confidence interval (CI) indicates that the indirect effect is significant, then indirect-only mediation exist (Zhao et al., 2010). In the current study, bias-corrected bootstrapped CIs were estimated for all statistics. Indirect effects were considered significant if either 95%, or 99% CIs did not overlap zero. Confidence limits for the indirect effect are usually based on critical values for the standard normal distribution. However, the indirect effect is typically not normally distributed in the population, thus the bias-corrected

bootstrapped method is recommended when estimating confidence intervals, because it corrects for this non-normality (Mackinnon, Lockwood, & Williams, 2004). Based on previous research (Zhao et al., 2010), 5,000 bootstrap samples were used in the current study. Additionally, the analyses were stratified by gender a priori, based on knowledge gained from chapter three (Aim 1) of this dissertation that gender modified the relationship between tobacco outlet exposure (i.e., density and proximity) and tobacco use. Furthermore, other environmental research examining correlates of the built environment and substance use among this cohort suggest that gender is a significant moderator of the relationship between the built environment and substance use (Brown et al., 2014; Lambert et al., 2004).

#### **4.4. Results**

##### **4.4.1. Sample Description**

Participants (n=230) were on average 22.2 years old, and there were approximately an equal percentage of males and females in the sample. The majority (52.6%) of participants had a history of tobacco use (i.e., reporting having ever used tobacco during or before 2007), but were not current (i.e., past month) marijuana (92.6%), or alcohol users (80.4%). Approximately 19% of the sample reported past month tobacco use, and the majority (76.5%) of participants had at least a high school diploma or GED. Sample characteristics are reported in Table 4.1. The mediation analysis was stratified by gender, and the results are reported in Tables 4.2-4.4.

##### **4.4.2. Mediation Analyses for Males**

Perceived harmfulness of cigarette use was not a significant mediator in the relationship between tobacco outlet exposure (i.e., density and proximity) and past month

tobacco use. Additionally, there were no significant direct paths from proximity to the closest tobacco outlet to past month tobacco use (Table 4.2). Disapproval of cigarette use significantly mediated the relationship between TO outlet density and past month tobacco use as indicated by the significant indirect effect (coefficient for indirect path [coef] = 0.247; 95% confidence interval [CI]: 0.003, 0.680) (Table 4.2). In the indirect path, TO outlet density was inversely associated with disapproval of cigarette use such that TO outlet density of 9.5 outlets or more per quarter mile (i.e., the median density or greater), relative to areas where TO outlet density was lower was associated with a 0.589 decrease in the predicted probability of strongly disapproving of cigarette use on the z-scale (Path A; Table 4.4). Furthermore, disapproval of cigarette use was inversely associated with past month tobacco use, such that strongly disapproving versus more favorable feeling toward cigarette use was associated with a 0.420 decrease in the predicted probability of past month tobacco use on the z-scale (Path B; Table 4.4). What this means in terms of relative risk is that men who lived in neighborhoods where TO outlet density was at the median or higher (and who also had no history of tobacco use up to 2007, who did not drink alcohol or use marijuana in the past month, had no friends who smoked cigarettes, had at least a high school education and enough money to meet their needs, and were in the control group for the baseline intervention), had a 23% decrease likelihood of strongly disapproving of cigarette use ( $RR = 0.77$ ), relative to men with the same characteristics, but who lived in areas where TO outlet density was lower than the median (Path A). Furthermore, in Path B, men who strongly disapproved of cigarette use relative to men who did not strongly disapprove had a 54% decrease likelihood of past month tobacco use ( $RR = 0.46$ ) given they perceived great risk in cigarette use, lived in



neighborhoods where density was below the median, had no friends who smoked cigarettes, had no history of tobacco use up to 2007, did not drink alcohol or use marijuana in the past month, had at least a high school education and enough money to meet their needs, and were in the control group for the baseline intervention.

Additionally, disapproval of cigarette use mediated the relationship between TA outlet density and past month tobacco use (coef = 0.275; 95% CI = -0.006, 0.761) (Table 4.2). In the indirect path, TA outlets density above zero outlets per quarter mile relative to having no TA outlets per quarter mile was associated with a 0.652 decrease in the predicted probability of strongly disapproving of cigarette use on the z-scale (Path A; Table 4.4). Moreover, strongly disapproving of cigarette use versus more favorable feelings toward cigarette use was associated with a 0.421 decrease in the predicted probability of past month tobacco use on the z-scale (Path B; Table 4.4). What this means in terms of relative risk is that men who lived in neighborhoods where TA outlet density was at the median or higher (and who also had no history of tobacco use up to 2007, who did not drink alcohol or use marijuana in the past month, had no friends who smoked cigarettes, had at least a high school education and enough money to meet their needs, and were in the control group for the baseline intervention), had a 36% decrease likelihood of strongly disapproving of cigarette use ( $RR = 0.64$ ), relative to men with the same characteristics, but who lived in areas where TA outlet density was lower than the median (Path A). Furthermore, in Path B, men who strongly disapproved of cigarette use relative to men who did not strongly disapprove had a 55% decrease likelihood of past month tobacco use ( $RR = 0.45$ ) given they perceived great risk in cigarette use, lived in neighborhoods where density was below the median, had no friends who smoked

cigarettes, had no history of tobacco use up to 2007, did not drink alcohol or use marijuana in the past month, had at least a high school education and enough money to meet their needs, and were in the control group for the baseline intervention.

#### 4.4.3. Mediation Analyses for Females

Among women, perceived harmfulness and disapproval of cigarette use did not mediate the relationship between tobacco outlet exposure (i.e., density and proximity) and tobacco use, as indicated by the lack of significant indirect pathways (Table 4.3). However in Path B, which explored the association between the mediators and the outcome, disapproval of cigarette use was inversely and significantly associated with past month tobacco use in each path model (Table 4.4). In a sensitivity analysis, which pooled men and women in the same model (n=230), all paths were estimated. There were no significant indirect or direct paths in the pooled model suggesting that perceived harmfulness and disapproval of cigarette use are not mediators of the relationship between tobacco outlet exposure (i.e., density and proximity) and past month tobacco use. Had the models not been stratified by gender, the significant indirect effects among men would have been missed. For example, in the unified model pooling men and women, the indirect path from TO outlet density through disapproval of cigarette use through past month tobacco use was not significant (coef = 0.116; 95% CI = -0.045, 0.332). However, when stratified by gender this indirect path was significant among men (n=118) (coef = 0.247; 95% CI = 0.003, 0.680), but not among women (n=112) (coef = -0.071; 95% CI = -0.518, 0.438), providing evidence for the gender stratified models over the unified models.

## **4.5. Discussion**

### **4.5.1. Summary**

The aim of this study was to explore perceived harmfulness and disapproval of cigarette use as potential mediators in the relationship between tobacco outlet exposure (i.e., density and proximity) and past month tobacco use. It was hypothesized that perceived harmfulness and disapproval of tobacco use would be mediators, and that results would vary by gender such that perceived harmfulness and disapproval of cigarette use would fully mediate the relationship between tobacco outlet exposure and past month tobacco use for women, and partially mediate this relationship for men. There were two central findings: First, disapproval of cigarette use was the only mediator that reached statistical significance. Second, mediation was only significant among males, such that disapproval of cigarette use fully mediated the relationship between TO outlet density and past month tobacco use, as well as TA outlet density and past month tobacco use.

### **4.5.2. Typology of Mediation and Theoretical Foundations**

Modern typology of mediation purports that indirect-only mediation is consistent with full mediation, which is the gold-standard, as opposed to partial mediation, which exist when both indirect and direct effects are significant (Zhao et al., 2010). Based on this typology, disapproval of cigarette use fully mediates the relationship (i.e., accounts for all of the variance) between tobacco outlet density and tobacco use for men, while neither partial nor full mediation was noted for women. Specifically, for men, higher tobacco outlet density is associated with a lower likelihood of strongly disapproving of cigarette use. Furthermore, strongly disapproving of cigarette use was inversely

associated with past month tobacco use. The relationship between tobacco outlet density, disapproval of cigarette use, and tobacco use among men is consistent with Social Cognitive Theory. Social Cognitive Theory suggests there is a significant interaction between behaviors, cognitions, and the environment (Bandura, 1986). Based on this theory, it is plausible that the widespread availability of tobacco outlets can be associated with the perceiving tobacco use normative, which in turn can be associated with subsequent tobacco use. Additionally, the density of outlets licensed to sell both tobacco and alcohol (i.e., TA outlets), relative to those licensed to sell tobacco only (i.e., TO outlets), was associated with a larger decrease in the predicted probability of strongly disapproving of cigarette use (i.e., men viewed cigarette use more favorably given TA outlet density, relative to TO outlet density). This information can lend to theory building. For example, males may frequent TA outlets more often than TO outlets, which may explain why there was a greater decrease likelihood of strongly disapproving of cigarettes use as a function of TA outlet density, as compared to TO outlet density. Furthermore, it is possible that the opportunity to purchase multiple drugs (e.g., tobacco and alcohol) place a role in whether or not males strongly disapprove of cigarette use.

Previous literature on this cohort, when participants were in the 7<sup>th</sup> through 9<sup>th</sup> grades found that beliefs about drug use, to include perceived harmfulness and disapproval of cigarette use, partially mediated the relationship between built environmental correlates of substance use (i.e., neighborhood disorder), and tobacco, alcohol, and marijuana use for men, while full mediation was observed for females (Lambert et al., 2004). The earlier results, together with the results of the current study suggest that mechanisms explaining the relationship between the built environment and

substance use may vary in magnitude over time as a function of development. The Ecological Model proposed by Bronfenbrenner (1994) posits that human development and the ecological system that it occurs in are inseparable. The Ecological Model is encapsulated by five nested systems – the *microsystem* (the environment as experienced by a person in a given face-to-face setting such as in family, peer, or school setting), the *mesosystem* (linkages taking place between two or more proximal settings such as the relationship between home and work), the *exosystem* (processes occurring between at least two settings, one of which does not include the developing person, such as the relationship between the youths' home environment and their parents' work place), the *macrosystem* (relates to culture and opportunity structure over the life-course), and the *chronosystem*, which encompasses change over time within the individual and within the surrounding environment (Bronfenbrenner, 1994). When applying this model to mechanism that explain the relationship between tobacco outlet exposure and tobacco use, the influence of macrosystem factors, such as exposure to tobacco outlet density during young adulthood, may be more salient in influencing beliefs about drugs during this time for men, as suggest by this study. For women, however, similar macrosystem factors in the built environment that lend to ease of access and availability of substances (Brown et al., 2014; Difranza et al., 1996; Lambert et al., 2004; Proctor et al., 2012; Robinson et al., 1998) may be more influential on beliefs about drug use (e.g., disapproval and harmfulness) during adolescence (e.g., middle and high school). In young adulthood for women, beliefs about drug use and other risk behaviors may be influence more by microsystem factors such as interaction with and perceptions of peer norms (Koval, Pederson, & Zhang, 2006; Stoddard, Bauermeister, Gordon-Messer,

Johns, & Zimmerman, 2012; Voisin, Hotton, Tan, & DiClemente, 2013). In summary, it is important to consider gender differences in mechanisms that drive the relationship between characteristics of the built environment (e.g., tobacco outlet density) and drug use, and how these factors may change over the life-course.

#### 4.5.3. Limitations

Inferences made based on this study must be interpreted with regard to limitations. First, tobacco, and other drug use were assessed via self-report, thus there was the potential for recall bias in the reported use of these substances. Additionally, all participants were African American, young adults, living in the inner-city, thus inferences may not be generalizable to other populations. Furthermore, given the high density of tobacco outlets in Baltimore City, results may not be generalizable to rural areas or geographic locations where tobacco outlet density is lower. Also, this study only assessed two potential mediators. Other mediating factors are possible. For example motivations toward a successful future, and efforts to maintain physical and mental health were inversely associated with drug use among young adult women (Koehn & O'Neill, 2011). These factors may be potential mediators in the relationship between tobacco outlet density and tobacco use. For instance, in areas where outlet density was highest, youth were offered drugs and witnessed drug related activity (Milam et al., 2013), which can potentially be inversely related to successful futures and health.

#### 4.5.4. Strengths

Notwithstanding limitations, this study extends the research base in this area by providing insight into potential mediating mechanisms of the relationship between tobacco outlet exposure and tobacco use. Additionally, the longitudinal design elucidates

temporality between the exposures, mediators, and distal outcome, which is an advantage over cross-sectional studies where temporality between variables is ambiguous.

Furthermore, this study provides insight into potential gender differences in the mechanisms explaining tobacco outlet exposure and tobacco use, which can lend to theory building and gender specific interventions.

#### **4.6. Conclusion**

The primary implication of this research calls for policy reform to reduce tobacco outlet density in residential areas. In addition, the results of this study can potentially lend to prevention efforts targeting social norms about tobacco use, especially beliefs about cigarette use. Future research should continue to explore mechanisms driving the relationship between tobacco outlet density and tobacco use in order to identify other factors malleable to preventive interventions, as well as to establish an arsenal of research encouraging policy reform aimed at reducing tobacco outlet density.

Table 4.1. Demographics characteristics of African American young adults living in Baltimore City (n=230)

Characteristics	n (%)
Gender	
Males	118 (51.3)
Females	112 (48.7)
Mean age in years <sup>+</sup> (SD)	22.2 (0.37)
Ever used tobacco <sup>+</sup>	
Yes	121 (52.6)
No	109 (47.4)
Past month marijuana use <sup>+</sup>	
Yes	17 (7.4)
No	213 (92.6)
Past month alcohol use <sup>+</sup>	
Yes	45 (19.6)
No	185 (80.4)
Education <sup>+</sup>	
≥ HS or GED	176 (76.5)
< HS or GED	54 (23.5)
Income <sup>+</sup>	
≥ enough to meet needs	125 (54.3)
< enough to meet needs	105 (45.7)
Friends smoke cigarettes <sup>+</sup>	
Yes	94 (40.9)
No	136 (59.1)
Median TO outlet density <sup>+</sup>	
≥ 9.5 outlets per quarter mile	111 (48.3)
< 9.5 outlets per quarter mile	119 (51.7)
Median TA outlet density <sup>+</sup>	
> 0 per quarter mile	77 (33.5)
= 0 per quarter mile	153 (66.5)
Median proximity to nearest TO outlet <sup>+</sup>	
≥ 381.96 meters	119 (51.7)
< 381.96 meters	111 (48.3)
Median proximity to nearest TA outlet <sup>+</sup>	
≥ 510.02 meters	118 (51.3)
< 510.02 meters	112 (48.7)
Perceived harmfulness of cigarette use <sup>*</sup>	
Great risk	123 (54.7)
No risk/slight risk/some risk	102 (45.3)
Strongly Disapproval of cigarette use <sup>**</sup>	
Yes	126 (56.0)
No	99 (44.0)
Past month tobacco use <sup>***</sup>	
Yes	39 (18.9)
No	167 (81.1)

+ assessed in 2007

HS = High School

GED = General Education Development (high school equivalency credentials)

TO = Outlets licensed to sell tobacco only;

TA = Outlets licensed to sell tobacco and alcohol

\* Assessed in 2008 among African American residents of Baltimore City with available data on perceived harmfulness of cigarette use (n = 225)



\*\*Assessed in 2008 among African American residents of Baltimore City with available data on disapproval of cigarette use (n = 225)

\*\*\*Assessed in 2009 among African American residents of Baltimore City with available data on past month tobacco use (n = 225)

Table 4.2. Probit regression estimates from path models assessing the mediating role of disapproval and perceived harmfulness of cigarette use in the relationship between tobacco outlet exposure and past month tobacco use among African American young adult males in Baltimore City, Maryland from 2007 through 2009 (n=118)

	Indirect effect		Direct Effect	Total Effect
	<u>Disapprove</u>	<u>Harm</u>		
<b>Density</b>				
TO Outlets	<b>0.247 (0.003, 0.680)</b>	0.006 (-0.101, 0.232)	-0.553 (-1.404, 0.256)	-0.300 (-1.060, 0.465)
TA Outlets	<b>0.275 (0.006, 0.761)</b>	0.022 (-0.228, 0.400)	-0.480 (-1.351, 0.404)	-0.183 (-1.077, 0.621)
<b>Proximity</b>				
TO Outlets	-0.174 (-0.564, 0.045)	-0.001 (-0.148, 0.123)	0.355 (-0.454, 1.166)	0.181 (-0.584, 0.943)
TA Outlets	-0.209 (-0.644, 0.023)	-0.036 (-0.472, 0.240)	0.648 (-0.263, 1.574)	0.402 (-0.373, 1.201)

- Significant paths are in bold
- 95% CI are in parentheses and are bias-corrected bootstrap confidence intervals estimated using 5,000 bootstrap samples
- TO = retail establishments licensed to sell tobacco (but not alcohol)
- TA = retail establishment licensed to sell both tobacco and alcohol
- Coefficients obtained from path analyses using probit regression
- The total effect is the sum of indirect and direct effect per path model
- The direct effect accounts for the association between tobacco outlet exposure and past month tobacco use adjusting for disapproval of cigarette use, perceived harmfulness of cigarette use, association with friends who smoke cigarettes, financial strain, education, past month alcohol use, past month marijuana use, history of tobacco use and design status at baseline

Table 4.3. Probit regression estimates from path models assessing the mediating role of disapproval and perceived harmfulness of cigarette use in the relationship between tobacco outlet exposure and past month tobacco use among African American young adult females in Baltimore City, Maryland from 2007 through 2009 (n=112)

	<b>Indirect effect</b>		<b>Direct Effect</b>	<b>Total Effect</b>
	<u>Disapprove</u>	<u>Harm</u>		
<b>Density</b>				
TO Outlets	-0.071 (-0.518, 0.438)	-0.127 (-0.569, 0.176)	0.519 (-0.587, 1.522)	0.322 (-0.584, 1.273)
TA Outlets	-0.042 (-0.475, 0.453)	0.015 (-0.362, 0.424)	0.190 (-0.768, 1.202)	0.163 (-0.757, 1.126)
<b>Proximity</b>				
TO Outlets	-0.035 (-0.577, 0.429)	0.049 (-0.277, 0.499)	-0.527 (-1.703, 0.618)	-0.513 (-1.597, 0.432)
TA Outlets	0.097 (-0.349, 0.609)	-0.138 (-0.615, 0.144)	-0.005 (-1.084, 1.061)	-0.046 (-1.058, 0.824)

- 95% CI are in parentheses and are bias-corrected bootstrap confidence intervals estimated using 5,000 bootstrap samples
- No paths were significant in table 4.3.
- TO = retail establishments licensed to sell tobacco (but not alcohol)
- TA = retail establishment licensed to sell both tobacco and alcohol
- Coefficients obtained from path analyses using probit regression
- CI: Confidence interval
- The total effect is the sum of indirect and direct effect per path model
- The direct effect accounts for the association between tobacco outlet exposure and past month tobacco use adjusting for disapproval of cigarette use, perceived harmfulness of cigarette use, association with friends who smoke cigarettes, financial strain, education, past month alcohol use, past month marijuana use, history of tobacco use and design status at baseline

Table 4.4. Probit regression estimates of Path A (exposure to mediators) and Path B (mediator to outcome) among African American young adults living in Baltimore City, Maryland from 2007 through 2009

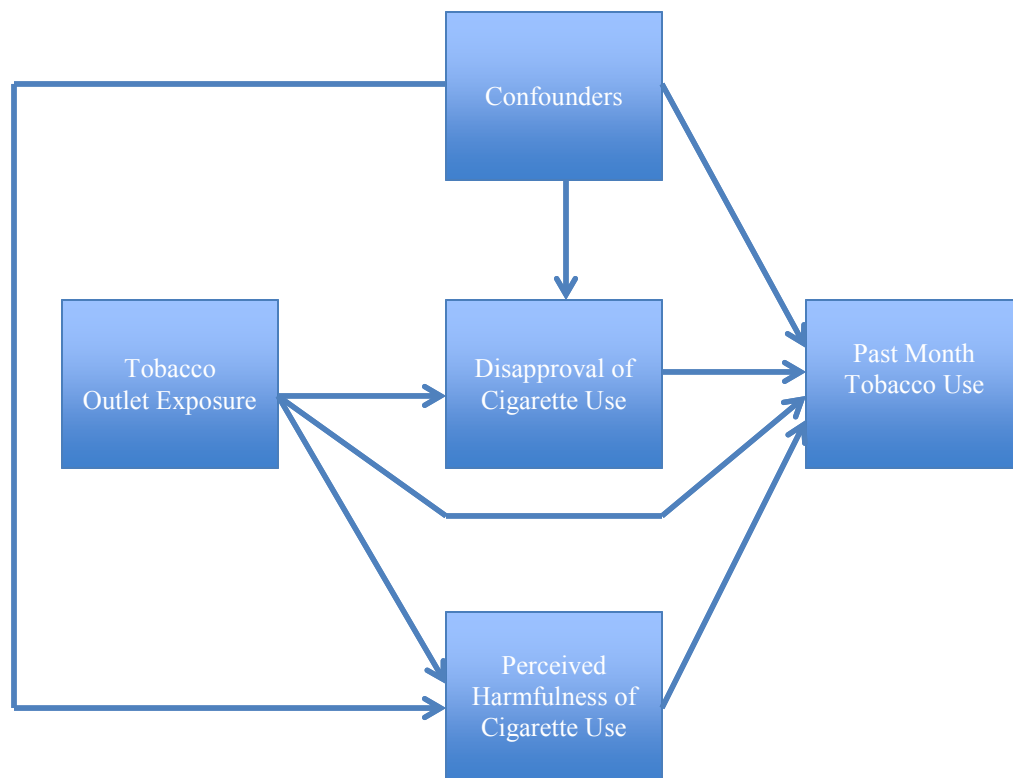
	<b>Males (n=118)</b>	<b>Females (n=112)</b>
<b>Path A (exposure to mediator)</b>	Coef. (CI)	Coef. (CI)
<u>Tobacco Only (TO) Outlets</u>		
Density to disapproval <sup>+</sup>	-0.589 (-1.135, 0.003)*	0.098 (-0.547, 0.662)*
Density to harm	-0.162 (-0.699, 0.421)*	0.292 (-0.331, 0.916)*
Proximity to disapproval	0.437 (-0.163, 0.983)*	0.047 (-0.537, 0.735)*
Proximity to harm	0.033 (-0.532, 0.592)*	-0.110 (-0.752, 0.479)*
<u>Tobacco/Alcohol (TA) Outlets</u>		
Density to disapproval	<b>-0.652 (-1.286, -0.020)*</b>	0.062 (-0.616, 0.671)*
Density to harm	-0.547 (-1.169, 0.107)*	-0.036 (-0.715, 0.717)*
Proximity to disapproval	0.510 (-0.096, 1.096)*	-0.137 (-0.792, 0.470)*
Proximity to harm	0.596 (0.030, 1.171)*	0.347 (-0.354, 0.962)*
<b>Path B (mediator to outcome)</b>		
<u>TO Outlet Density Model</u>		
Disapproval to tobacco use	<b>-0.420 (-0.734, -0.043)*</b>	<b>-0.726 (-1.000, -0.081)**</b>
Harm to tobacco use	-0.036 (-0.448, 0.387)*	-0.433 (-0.795, 0.181)*
<u>TO Proximity Model</u>		
Disapproval to tobacco use	<b>-0.397 (-0.698, -0.011)*</b>	<b>-0.751 (-1.000, -0.142)**</b>
Harm to tobacco use	-0.031 (-0.447, 0.390)*	-0.450 (-0.812, 0.195)*
<u>TA Outlet Density Model</u>		
Disapproval to tobacco use	<b>-0.421 (-0.741, -0.054)*</b>	<b>-0.681 (-1.000, -0.024)**</b>
Harm to tobacco use	-0.041 (-0.442, 0.388)*	-0.404 (-0.775, 0.195)*
<u>TA Proximity Model</u>		
Disapproval to tobacco use	<b>-0.410 (-0.737, -0.037)*</b>	<b>-0.706 (-1.000, -0.098)**</b>
Harm to tobacco use	-0.061 (-0.481, 0.364)*	-0.396 (-0.756, 0.183)*

- Significant paths are in bold
- CIs are bias-corrected bootstrap confidence intervals (\*95% CI and \*\*99% CI) estimated using 5,000 bootstrap samples
- + Considering the indirect effect from TO outlet density through disapproval of cigarette use to past month tobacco use was significant, it is important to note that Path A from TO outlet density

to disapproval of cigarette use had a p-value = 0.048, and a significant 90% CI (90% CI = -1.038, -0.083)

- TO = retail establishments licensed to sell tobacco (but not alcohol)
- TA = retail establishment licensed to sell both tobacco and alcohol
- Coef: Coefficients were estimated using probit regression via path analyses
- Paths A adjusts for, financial strain, education, past month alcohol use, past month marijuana use, history of tobacco use, association with friends who smoke cigarettes, and design status at baseline
- Path B adjusts for disapproval of cigarette use, perceived harm of cigarette use, the exposure of interest (either tobacco outlet density or proximity), financial strain, education, past month alcohol use, past month marijuana use, history of tobacco use, association with friends who smoke cigarettes, and design status at baseline

Figure 4.1: Conceptual model depicting mediation



**Chapter 5:** The growth of tobacco outlet density and tobacco use among African American young adults in Baltimore City: A parallel process

**5.1. Abstract**

Introduction: There is a lack of longitudinal data explaining the relationship between tobacco outlet density and tobacco use. This study aims to assess the correlation between the growth of tobacco outlet density and past month tobacco use among African American young adults living in Baltimore City, Maryland. Methods: This study used parallel process latent growth curve modeling to evaluate the simultaneous growth of tobacco outlet density and past month tobacco use among African American young adults living in Baltimore City from 2006 through 2009. Geospatial methods were used to estimate tobacco outlet density within the immediate lived environment. Results: The correlation between the random effects on the slopes of past month tobacco use and tobacco outlet density were positive but not statistically significant ( $r = 0.31$ ;  $p\text{-value} = 0.08$ ). However, the correlation between the random effects on the intercepts of past month tobacco use and tobacco outlet density was statistically significant ( $r = 0.19$ ;  $p\text{-value} < 0.05$ ). Conclusion: Baseline tobacco outlet density in residential neighborhoods is a more salient correlate of tobacco use behaviors relative to changes in tobacco outlet density among African American young adults living in urban environments. Policy efforts should consider zoning restrictions that prohibit the establishment of tobacco outlets in residential neighborhoods, effectively ensuring a baseline density of zero.

## **5.2. Introduction**

In the US past month tobacco use (i.e., current tobacco use) has decreased over the past decade among people 12 years old and older (SAMHSA, 2013). However the percentage of young adults 18 to 25 years old who currently use tobacco is higher than any other age group. For example, in 2012, 38.1% of young adults used tobacco in the past month, compared to 8.6% of adolescents 12 to 17 years old, and 27% of persons 26 years old and older (SAMHSA, 2013). According to the US Surgeon General, in order to end the tobacco epidemic, prevention efforts must focus on youth and young adults, and account for environmental influences to smoke (Services, 2012).

Characteristics of the built environment such as neighborhood disorder, and exposure to tobacco and alcohol outlets pose risk for tobacco and other drug use and warrant further attention (Brown et al., 2014; Henriksen et al., 2008; Lambert et al., 2004; Lipperman-Kreda et al., 2012b; Sharon Lipperman-Kreda et al., 2013; Maimon & Browning, 2012; Milam et al., 2014). For example, tobacco outlets, are facets of the built environment that overtly and deliberately promote tobacco use through sales and advertisements often targeted toward youth and minorities (Agaku & Ayo-Yusuf, 2014; Cruz, Wright, & Crawford, 2010; Seidenberg, Caughey, Rees, & Connolly, 2010), and high outlet density is often found in disadvantaged minority communities (Fakunle et al., 2010; Peterson et al., 2011; Rodriguez et al., 2012a; Schneider et al., 2005; Yu et al., 2010). Several studies, which found a positive relationship between tobacco outlet density and tobacco use, conclude that reducing tobacco outlet density will be associated with reductions in tobacco use (Henriksen et al., 2008; Lipperman-Kreda et al., 2013; McCarthy et al., 2009; Novak et al., 2006). However, there is limited evidence on the

longitudinal relationship between tobacco outlet density and tobacco use. One study assessed the longitudinal association between exposure to tobacco advertisement at retail outlets and smoking initiation among middle to high school students, and found that greater exposure to tobacco advertisement was associated with smoking initiation at 12 and 30 months after baseline assessment of smoking status among never smokers (Henriksen, Schleicher, Feighery, & Fortmann, 2010). Among adult smokers, tobacco outlet density was not associated with smoking behaviors over time (Han, Alexander, Niggebrugge, Hollands, & Marteau, 2014; Reitzel et al., 2011) – however the relationship between changes in density over time and tobacco use was not assessed. In fact, no studies were found that explored the association between changes in tobacco outlet density and changes in tobacco use. Empirical information regarding this association will provide valuable insight into the mechanisms driving the relationship between tobacco outlet density and tobacco use over time, and this gap in the extant literature is addressed in the current study.

The current study addresses this gap by simultaneously exploring changes in tobacco outlet density and past month tobacco use over four years, among African American young adults living in Baltimore City, Maryland. It is hypothesized that the growth of tobacco outlet density and the growth of past month tobacco use will be positively and significantly correlated. This research is timely considering the health initiative of the Baltimore City Health Department to reduce the percent of adults and teens that currently smoke by 20% by 2015 (Spencer et al., 2011). Furthermore, the Institute of Medicine recommends restricting the density and location of tobacco outlets in order to promote public health (IOM, 2007). The current study will explore tobacco



outlet density at the neighborhood level (i.e., with a quarter mile of participants' homes) in order to give insight on the mechanisms driving the relationship between tobacco outlet density and tobacco use in residential neighborhoods. Previous research provides evidence the neighborhood environment immediately surrounding where people live is important in substance use outcomes (Brown et al., 2014; Furr-Holden et al., 2011; Lambert et al., 2004; Milam et al., 2014).

### **5.3. Methods**

#### **5.3.1. Participants**

Participants (n= 308) in the current study were African American young adults residing in Baltimore City, Maryland from 2006 to 2009. The analytic sample was derived from a larger cohort of 799 students who participated in the Johns Hopkins Second Generation Baltimore Prevention Program (BPP) intervention in the first grade in 1993. The BPP is a field trial of two universal first grade interventions and respondents were followed through adulthood (Ialongo et al., 1999). Inclusion criteria for the current study were limited to African American participants who lived in Baltimore City, because tobacco outlet data was only available for City residents, and 96% of the participants (n= 308) living in Baltimore City beginning in 2006 were African American, limiting the ability to detect differences by race.

A total of 593 participants completed the BPP interview in 2006, and 322 lived in Baltimore City – 308 (96%) were African American, and 14 were white (4%). The 308 African American participants were included in the current study and followed through 2009. Of the 308 participants who met inclusion criteria, 2.9% (n=9) were missing information on a control variable (i.e., association with friends who smoke cigarettes),

and were not included in the adjusted model. The parallel processes growth model was estimated using maximum likelihood with robust standard errors (MLR). Maximum likelihood methods find values of the model parameters that make the observed data most probable under the given model (Cole, Chu, & Greenland, 2014). Furthermore, this model estimation maximized use of all information by allowing missingness to be a function of the observed covariates, but not the observed outcomes, such that participants were only excluded from the model if they were missing on exogenous variables (Muthén & Muthén, 1998-2012). Of the 593 participants interviewed in 2006, those included in the analytic sample ( $n = 308$ ) did not differ significantly from those excluded ( $n = 285$ ) with regard to any of the measured covariates – baseline intervention status, number of friends who smoke cigarettes, education, past month alcohol use, past month marijuana use, history of tobacco use, age, or gender. There were two outcomes of interest in the current study, past month tobacco use and tobacco outlet density, both measured at four time points (i.e., 2006 through 2009). Participants included in the analytic sample did not differ from those excluded on past month tobacco use in 2008 and 2009, but did significantly differ in 2006 and 2007. In 2006, among those included in the analytic sample, 16% ( $n = 49$ ) of participants used tobacco in the past month relative to 23% ( $n = 66$ ) of participants not included ( $\chi^2 = 4.8$ ,  $df = 1$ ,  $p < 0.03$ ). In 2007, 12% ( $n = 36$ ) of participants in the analytic sample used tobacco in the past month, relative to 22% ( $n = 63$ ) of participants excluded ( $\chi^2 = 11.6$ ,  $df = 2$ ,  $p < 0.03$ ). The majority of participants not included in the analytic sample (95%), did not live in Baltimore City. Environmental stressors potentially associated with tobacco use, such as tobacco outlet density outside of

the city limits may help explain the differences in past month tobacco use between the analytic sample and those excluded from the study in 2006 and 2007.

### 5.3.2. Data Sources

#### 5.3.2a. Baltimore Prevention Program (BPP) Data

1993, a total of 678 first grade students and their families, representative of the number of students entering first grade in nine public elementary schools in Baltimore City, were recruited to participate in the BPP trial to evaluate two first grade preventive interventions – a classroom centered (CC) intervention, and family-school partnership (FSP) interventions – aimed at improving academic success, reducing concentration problems, and reducing aggressive and shy behaviors (Ialongo et al., 1999). The proximal targets of both the FSP and the CC interventions were to prevent poor academic achievement, reduce concentration problems, and reduce aggressive and shy behaviors – known early risk factors for later substance use disorders (Ialongo et al., 1999). The distal targets of these interventions were to prevent risk of substance abuse, depression, and antisocial behavior (Ialongo et al., 1999). Three classrooms from each of the nine schools were randomized to either of the two interventions arms or the control arm (standard classroom setting) of the trial (Ialongo et al., 1999). An additional 121 participants transferred into the participating schools after the baseline assessments, for a total sample size of 799. A description of the original study sample is reported in previous research (Ialongo et al., 1999). Annual assessment of tobacco and other drug use for this cohort started in the sixth grade (Wang et al., 2009; Wang et al., 2012). The Institutional Review Board at The Johns Hopkins Bloomberg School of Public Health approved this study.

### 5.3.2b. Tobacco Outlet Data

Data on retail establishments licensed to sell cigarettes (e.g., smoke shops, corner stores, grocery stores) in Baltimore City were obtained for 2006 through 2009 from the Circuit Court for Baltimore City, Land Records and License Division office. The Circuit Court provided a total of 1,567 retail addresses in 2006; 1,535 in 2007; 883 in 2008; and 1,184 in 2009. Duplicate addresses were removed based on latitude and longitude, and the remaining addresses were analyzed in this study. In 2006, 94 duplicate locations were removed and the remaining 1,473 outlets were analyzed. In 2007, 97 duplicate locations were removed and the remaining 1,438 outlets were analyzed. In 2008, 57 duplicate locations were removed and the remaining 826 outlets were analyzed. In 2009, 52 duplicate locations were removed and the remaining 1,133 outlets were analyzed.

### 5.3.3. Measures

#### 5.3.3a. Outcomes

Two outcomes were assessed – past month tobacco use and tobacco outlet density – from 2006 through 2009. The BPP assessment measures recency of tobacco use using questions from the Monitoring the Future Nation Survey (Johnston et al., 1995), which asked participants whether or not they used tobacco within the last week, month, year, or over a year ago. Audio computer-assisted self-interview (ACASI) methods were used to assess tobacco use to promote privacy, and to obtain accurate and complete responses (Storr et al., 2002). Participants who reported having used tobacco within the past month were considered current users. A binary variable was used to measure tobacco use at each time point. Tobacco use anytime within the past month was coded 1, otherwise 0.

Tobacco outlets density was assessed annually from 2006 through 2009. The density measures were created by dividing the count of tobacco outlets within a quarter

mile network buffer of participants' homes by the area of each buffer, yielding a continuous measure of density per quarter mile. Studies examining exposure to tobacco outlets, typically estimate walking distance between a quarter mile and one mile (Henriksen et al., 2008; Lipperman-Kreda et al., 2013; McCarthy et al., 2009; West et al., 2010). Currently, there is no gold standard to define a buffer size representative of a person's immediate neighborhood environment (West et al., 2010). In the current study, a quarter mile was used to measure walking distance because in urban centers the density of and access to commercial businesses is typically greater, and residential walking distance is often shorter than a half mile (Milam et al., 2014).

#### 5.3.4. Spatial Analysis

Tobacco outlet locations were geocoded using ArcGIS v.10.1 (ESRI, 2012). Geocoding is the process used to assign a spatial location to an address record (Waller & Gotway, 2004). Each BPP participant address record already had a latitude and longitude value assigned to it, so geocoding of participants' home addresses was not necessary. Quarter mile network buffers (i.e., walking distance) were added around each participant's home using the Network Analysis extension Service Area tool in ArcGIS, which accounts for navigating street networks, as compared to straight-line distance, which ignores street networks. The count of tobacco outlets per quarter mile was determined using the spatial joining tool in ArcGIS. Spatial joining is a process used to combine multiple map layers (e.g., geocoded tobacco outlet files and buffered distance information) into one data set (Waller & Gotway, 2004).

### 5.3.5. Statistical Analysis

Descriptive analyses were carried out to characterize the population using Stata/SE version 13 (Stata, 2013). Parallel process growth curve modeling was used to explore the correlation between changes in tobacco outlet density and past month tobacco use from 2006 to 2009 using Mplus version 7.1 (Muthén & Muthén, 1998-2012). This model is called a parallel process growth model because multiple growth processes (i.e., tobacco outlet density, and past month tobacco use) are simultaneously included in the growth model (Gross & Rebok, 2011). The intercepts and slopes are latent growth factors (Muthén & Muthén, 1998-2012). In this model, the time scores of the slopes for both tobacco outlet density and tobacco use were fixed at 0, 1, 2, and 3 representing equidistant time points (Muthén & Muthén, 1998-2012). The zero time score for the slope growth factor at the first time point characterizes the intercept factors as the initial status factors (Muthén & Muthén, 1998-2012). The coefficients of the intercept growth factors are fixed at one as part of the parameterization of the growth model (Muthén & Muthén, 1998-2012). Furthermore, the residuals variances of the outcome variables are estimated and allowed to vary across time, and the residuals are not correlated (Muthén & Muthén, 1998-2012). Figure 5.1 describes the estimated model.

## 5.4. Results

In 2006, participants (n=308) were on average 19 years old, and there were approximately an equal percentage of males and females. The majority of participants (65.6%) had at least a high school diploma or GED. Current tobacco use (i.e., past month use) ranged from 11.8% to 17.9% from 2006 to 2009. Sample characteristics are reported

in Table 5.1. The fitted intercepts and slopes for tobacco outlet density and past month tobacco use are reported in Table 5.2. The correlation between the random effects on the slopes of tobacco outlet density and past month tobacco use were positively related but not significantly correlated ( $r = 0.31$ ;  $p\text{-value} = 0.08$ ). However, there was a positive and significant correlation between the random effects on the intercepts for past month tobacco use and tobacco outlet density ( $r = 0.19$ ;  $p\text{-value} < 0.05$ ). In addition, there were significant negative correlations between the random effects on the intercept for tobacco outlet density and the random effects on the slopes for past month tobacco use and tobacco outlet density. The correlation between the random effects on the intercept and slope for past month tobacco use was significant and negative. Correlations between these latent growth factors are reported in Table 5.3. The formulas used to convert the covariances to correlations are

$$(I, S) = \text{Covariance } (I, S) / \sqrt{[(\text{variance } I) * (\text{variance } S)]} \text{ or}$$

$$(S_1, S_2) = \text{Covariance } (S_1, S_2) / \sqrt{[(\text{variance } S_1) * (\text{variance } S_2)]}$$

## **5.5. Discussion**

### **5.5.1. Summary**

The primary aim of this study was to assess the correlation between the growth of tobacco outlet density and past month tobacco use among African American young adults living in Baltimore City, Maryland from 2006 to 2009. The hypothesis was centered around the correlation between the random effects on the slopes between tobacco outlet density and past month tobacco use. It was hypothesized that there would be a positive and significant correlation between the growth of tobacco outlet density and the growth of past month tobacco use. Evidence partially supports this hypothesis such that the

relationship was positive, but not statistically significant. The correlation between other growth factors were however statistically significant.

#### 5.5.2. Theoretical insight on the relationships between latent growth factors of tobacco outlet density and past month tobacco use

The positive correlation between the random effects on the slopes of tobacco outlet density and past month tobacco use, as well as the positive and significant correlation between the random effects on the intercepts of these growth factors are consistent with previous cross-sectional research, which reveals positive association between tobacco outlet density and tobacco use (Henriksen et al., 2008; Sharon Lipperman-Kreda et al., 2013; McCarthy et al., 2009; Novak et al., 2006). This study extends the literature base by lending insight to specific mechanisms that might be more salient to understanding the relationship between tobacco outlet density and tobacco use. For example, although the random effects on the slopes of tobacco outlet density and past month tobacco use were in the expected direction the relationship was not significant. Thus, it appears that other growth factors which were significantly correlated – such as the relationship between the random effects on the intercepts of tobacco outlet density and past month tobacco use, and the relationship between the random effects on the intercept for tobacco outlet density and the slope for past month tobacco use – are more prominent in driving the relationship between tobacco outlet density and tobacco use. For example, the significant positive correlation between the random effects on the intercepts between the two outcomes suggest that the prevalence of past month tobacco use will be initially low among African American young adults who live in neighborhoods where tobacco outlet density starts off low, whereas the prevalence of past month tobacco use



will be initially high among African American young adults who live in neighborhoods where tobacco outlet density is initially high. Therefore, initial (e.g., baseline) tobacco outlet density, relative to changes in tobacco outlet density over time is the more salient correlate of current tobacco use among this population.

Tobacco access behaviors may help explain the relationships between the growth factors. For example, in 2006, the baseline for the current study, young adults were on average 19 years old (range: 18 to 20 years old), thus just entering the age range where they could legally purchase tobacco products (DiFranza, 2012). Thus, young adults may have initially purchased tobacco from tobacco outlets during this time, which helps explain the significant and positive relationship between the random effects on the intercepts of tobacco outlet density and past month tobacco use. However, tobacco access behaviors may change over time for young adults. For example, the buying and selling of single cigarettes (e.g., loosies) through an informal economic structure (e.g., purchasing single cigarettes from someone on the street) is prevalent among African Americans young adults in Baltimore City, and is a preferred acquisition practice (Smith et al., 2007). This alternative way of purchasing cigarettes, which does not involve direct purchase from tobacco outlets, influences tobacco use and perceived norms about tobacco use among this population (Smith et al., 2007; Stillman, Bone, & Avila-Tang, 2007; Stillman, Bone, Milam, Ma, & Hoke, 2014), which helps explain the non-statistically significant relationship between changes in tobacco outlet density and changes in past month tobacco use over time.

This study also found three negative and significant relationships – between the random effects on the intercept for tobacco outlet density and the slope for past month

tobacco use; between the random effects on the intercept and slope for past month tobacco use; and between the random effects on the intercept and slope of tobacco outlet density. The relationship regarding the random effects of the intercept for tobacco outlet density and the slope for past month tobacco use is not consistent with other longitudinal studies exploring the relationship between tobacco outlet exposure and tobacco use. For example, one study found that greater exposure to tobacco advertisement at retail outlets was associated with smoking initiation over time (Henriksen et al., 2010). Another study found that proximity to tobacco outlets, but not tobacco outlet density was associated with long term smoking outcomes (Reitzel et al., 2011), and yet another study found that neither density nor proximity were associated with tobacco use over time (Han et al., 2014). However, there is limited longitudinal evidence relating tobacco outlet density to tobacco use, and additional research is needed to build the literature base in this area and to corroborate these findings. The negative relationship between the random effects on the intercept and slope for past month tobacco use may be explained by tobacco use trajectories. For example, one study found four smoking trajectories among African American and Puerto Rican young adults living in the inner-city. These trajectories included nonsmokers, maturing-out smokers, late-starting smokers, and early-starting continuous smokers (Brook, Ning, & Brook, 2006). Participants in the current study who initially used tobacco may have matured-out of tobacco use over time, which helps explain the negative correlation between the random effects on the intercepts and slopes of past month tobacco use. Likewise, participants who initially were not current tobacco users may have adopted tobacco use over time, analogous to late-starting smokers. The final significant finding of this study was with regard to the negative relationship between

the random effects on the intercept and slope of tobacco outlet density. This finding is consistent with literature suggesting that tobacco advertisement is targeted toward youth and minorities (Agaku & Ayo-Yusuf, 2014; Cruz et al., 2010; Seidenberg et al., 2010). Therefore, if tobacco outlet density is initially low, it is logical that density would increase over time in inner-city minority neighborhoods in effort to promote tobacco advertisement and use in these communities. Additionally, it is reasonable that if tobacco outlet density is high initially, that slope in density would decrease over time, considering alternative means of purchasing tobacco such as through the purchase of loose cigarettes among this population (Smith et al., 2007; Stillman et al., 2007; Stillman et al., 2014). These two explanations – tobacco advertisement, and alternative purchasing practices – lend insight to the negative relationship between the random effects on the intercept and slope of tobacco outlet density.

#### 5.5.3. Limitation

Inferences made based on this study must be interpreted with regard to limitations. First, only recency of tobacco use (e.g., past month use) was explored in this study. Although past month use is characteristic of current tobacco use and is frequently used to measure tobacco use among youth and young adults (SAMHSA, 2011, 2012, 2013), other measures of tobacco use such as the number of cigarettes smoked per day may yield different results with regard to the association between tobacco use and tobacco outlet density. Considering there is no safe level of tobacco use (Services, 2010), this study should be replicated to explore the relationship between tobacco outlet density and number of cigarette smoked per day. Additionally, this study restricted the sample based on race and geographic location, which are important factors associated with

tobacco outlet density and tobacco use. However, future research should consider modeling predictors from a multi-level framework, which would include potential macro level predictors such as policy, as well as individual level covariates. Additionally, results from this study may not be generalizable to other populations (e.g., rural communities) considering the sample was restricted to African American young adults living in the inner-city.

#### 5.5.4. Strengths

This study is an initial step toward understanding the relationship between the simultaneous growth of tobacco outlet density and tobacco use among African American young adults living in urban environments, and provides a platform from which future research seeking to understand this relationship can build upon. This study adds new information to the literature base in this area by elucidating the relationship between latent growth factors of tobacco outlet density and tobacco use, and by helping to disentangle salient characteristics of this relationship from those that are not as significant. Inferences from this study may inform policy efforts aimed at reducing tobacco outlet density in residential neighborhoods, and lend to theory building with regard to the relationship between the built environment and tobacco use.

### **5.6. Conclusions**

Considering that baseline tobacco outlet density in residential neighborhoods, relative to changes in tobacco outlet density over time is a salient correlate of tobacco use among African American young adults living in the inner-city, policy efforts should consider zoning restrictions that prohibit the establishment of retail tobacco outlets in urban residential neighborhoods, effectively ensuring a baseline density of zero.

Figure 5.1. Parallel process growth model for tobacco outlet density and past month tobacco use from 2006 to 2009 among African American young adults living in Baltimore City, Maryland.

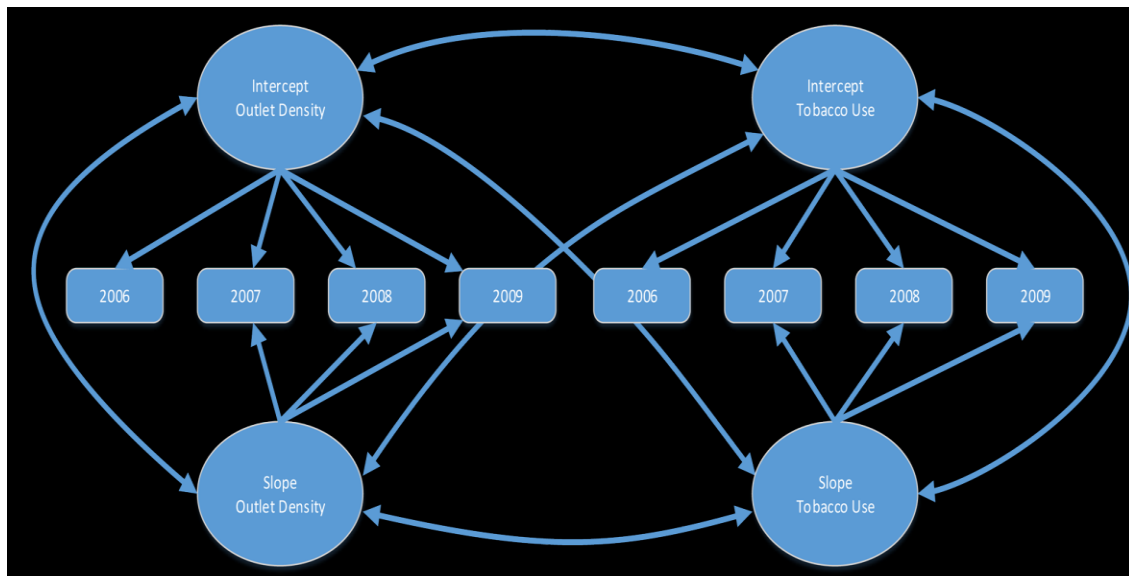


Table 5.1: Demographics characteristics of African American BPP participants (n=308)

Characteristics	n (%)	n (%) Missing
Gender		0 (0.0)
Males	159 (52.6)	
Females	149 (48.4)	
Mean age in years (SD)	19 (0.37)	0 (0.0)
Ever used tobacco		0 (0.0)
Yes	153 (49.7)	
No	155 (50.3)	
Past month marijuana use		0 (0.0)
Yes	34 (11.0)	
No	274 (89.0)	
Past month alcohol use		0 (0.0)
Yes	62 (20.1)	
No	246 (79.9)	
Education		0 (0.0)
≥ HS or GED	202 (65.6)	
< HS or GED	106 (34.4)	
Friends smoke cigarettes		9 (2.9)
Yes	139 (46.5)	
No	160 (53.5)	
Past month tobacco use		
2006		0 (0.0)
Yes	49 (15.9)	
No	259 (84.1)	
2007		34 (11.0)
Yes	36 (13.1)	
No	238 (86.9)	
2008		28 (9.1)
Yes	33 (11.8)	
No	247 (88.2)	
2009		34 (11.0)
Yes	49 (17.9)	
No	225 (82.1)	
Tobacco Outlet Density <sup>+</sup>		0 (0.0)
Median (2006)	9.6	
Median (2007)	11.9	
Median (2008)	4.1	
Median (2009)	9.4	

- + Density measures were calculated for all participants who lived in Baltimore City at each time point
- All variables were assessed in 2006 unless otherwise noted
- GED = General Education Development (high school equivalency credentials)
- SD = Standard Deviation

Table 5.2. Fitted intercepts and slopes for tobacco outlet density and past month tobacco use among African American BPP Participants living in Baltimore City, Maryland from 2006 -2009 (n=308)

	Tobacco Outlet Density $\beta$ (SE)	Past Month Tobacco Use $\beta$ (SE)
Intercept	24.292 (1.995)**	-6.975 (0.738)**
Slope	-2.807 (0.797)**	0.828 (0.393)*

- SE – Standard error
- \*\* p-value < 0.01; \* p-value < 0.05
- Intercepts are log odds and slopes are log odd ratios for past month tobacco use, but not for tobacco outlet density

**Table 5.3.** Correlations between random effects on intercepts and slopes for tobacco outlet density and past month tobacco use among African American BPP Participants living in Baltimore City Maryland from 2006 -2009 (n=308)

	Intercept outlet density	Slope tobacco use	Slope outlet density
Intercept tobacco use	0.19*	- 0.79**	- 0.15
Intercept outlet density	--	- 0.25*	- 0.76**
Slope tobacco use	--	--	0.31

\*\*p-value  $\leq$  0.01; \* p-value < 0.05

## **Chapter 6: Discussion**

### **6.1. Summary of primary findings**

The goal of this dissertation was to elucidate mechanisms underlying the relationship between exposure to tobacco outlets and past month (i.e., current) tobacco use among African American young adults living in Baltimore City, Maryland. Using geospatial methods, tobacco outlet density and proximity were assessed in the immediate lived environment (i.e., within walking distance of participants' homes). Chapter 3 of this dissertation explored gender as a potential moderator of the relationship between tobacco outlet exposure and past month tobacco use and found that gender significantly moderated the relationship between tobacco outlet density (but not proximity to nearest outlet) and tobacco use such that results were positive and significant only among women, and the strength of the association varied depending on whether or not the outlet was licensed to sell tobacco only (TO outlets) or both tobacco and alcohol (TA outlets). Specifically, after controlling for confounders, only the relationship between TO outlet density and past month tobacco use was statistically significant. Chapter 4 explored perceived harmfulness and disapproval of cigarette use as potential mediators in the relationship between tobacco outlet exposure and past month tobacco use. The two central findings from this chapter were that 1. disapproval of cigarette use, but not perceived harmfulness of cigarette use, significantly mediated the relationship between tobacco outlet density (TO and TA) and past month tobacco use, and 2. this relationship was only significant for males. The paths between proximity to the nearest tobacco outlet and past month tobacco use were not significantly mediated by either perceived



harmfulness or disapproval of cigarette use. In chapter 5, the simultaneous growth of tobacco outlet density and past month tobacco use was explored. Correlations between several latent growth factors were measured and of primary interest was the correlation between the random effects on the slopes of tobacco outlet density and past month tobacco use. This correlation was in the expected direction (i.e., positive), but not statically significant. However, the random effects on the intercepts of tobacco outlet density and past month tobacco use were positively and significantly correlated suggesting that baseline tobacco outlet density is the more salient correlate of tobacco use among this population.

## **6.2. Limitations**

Results from this study should be interpreted with regard to certain limitations. First, all participants were African American young adults living in the inner-city. This population is often the target of tobacco advertisements (Agaku & Ayo-Yusuf, 2014; Cruz et al., 2010; Seidenberg et al., 2010), and tobacco outlet density is typically greater in disadvantage, minority neighborhoods (Fakunle et al., 2010; Peterson et al., 2011; Rodriguez et al., 2012a; Schneider et al., 2005; Yu et al., 2010). However, considering the homogeneity of this sample with regard to race and geographic location, results from this study may not be generalizable to other populations (e.g., suburban or rural communities, or other races/ethnicities). Additionally, tobacco and other drug use were assessed via self-report, thus there was the potential for recall bias in the reported use of these substances. Furthermore, this study only assessed two potential mediators – perceived harmfulness and disapproval of cigarettes use. Future research should assess other potential mediators, such as motivations toward a successful future, and perceptions

of physical and mental health. Moreover, tobacco use was captured via past month use. Considering there is no safe level of exposure to tobacco use (Services, 2010), other measures of use such as cigarettes smoked per day may yield different results, and should be considered in future research.

### **6.3. Strengths**

Notwithstanding limitations, this research adds value to the literature base in this area. For example, there are only a few studies assessing the relationship between tobacco outlet exposure and tobacco use, and none focus exclusively on African American young adults living in the inner-city. Additionally, this study elucidates the moderating role of gender on environmental cues to use tobacco, which may lead to gender specific interventions. For example, in the US, 21% of pregnant women 18 to 25 years old are current smokers (SAMHSA, 2013). Understanding gender differences in built environmental correlates of tobacco use can potentially inform maternal and child health efforts aimed at reducing tobacco use among young adult women who are pregnant. Furthermore, in two aims (chapters 3 and 4), tobacco outlets were classified based on whether or not they were licensed to sell tobacco only (TO outlets) or tobacco and alcohol (TA outlets). Classifying these outlets separately provides insight into the independent association each type of outlet has on tobacco use – a distinction that has been overlooked in previous research. Furthermore, this is the first study to the author's knowledge to assess multiple mechanisms (i.e., moderation, mediation, and growth) of the relationship between tobacco outlet density and tobacco use making this a timely and important contribution to the science in this area.

#### **6.4. Conclusion**

Tobacco outlet density is a malleable environmental correlate of tobacco use, and high outlet density in vulnerable communities undermines public health efforts to reduce tobacco use and health disparities associated with tobacco use among marginalized groups. This study lends to a more comprehensive understanding of the mechanisms driving the relationship between tobacco outlet exposure and tobacco use among African American young adults living in the inner city, and the findings can inform research, practice, and policy efforts aiming to reduce tobacco use among this population. High tobacco outlet density in urban neighborhoods has a hazardous influence on tobacco use, as well as on beliefs about tobacco use among African American young adults. There are many possible solutions to address the tobacco outlet density problem to include zoning restrictions that prohibit the establishment of tobacco retail outlets in residential communities, incentive programs that reward retailers for choosing not to sell tobacco, prohibiting certain establishments (e.g., pharmacies) from being eligible to sell tobacco products, and enacting a moratorium on new licenses to help control spikes in tobacco outlet density to name a few (Cohen & Anglin, 2009). Researchers, practitioners, and policy makers should work in unison to comprehensively reduce tobacco use and the establishment of tobacco outlets in residential communities – especially minority communities where tobacco outlets are ubiquitous.

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## Appendix A: IRB Approval



FWA #00000287

### JHSPH Institutional Review Board Office *Institutional Review Boards*

615 N. Wolfe Street / Suite E1100  
Baltimore, Maryland 21205  
Office Phone: (410) 955-3193  
Toll Free: 1-888-262-3242  
Fax Number: (410) 502-0584  
E-mail Address: [irboffice@jhsp.edu](mailto:irboffice@jhsp.edu)  
Website: [www.jhsp.edu/irb](http://www.jhsp.edu/irb)

### AMENDMENT APPROVAL NOTICE EXPEDITED REVIEW

**Date:** May 22, 2013

**To:** Nichole Ialongo, PhD  
*Department of Mental Health*

**From:** Joanne Katz, ScD  
Chair, IRB-FC

**Re:** **Study Title:** "Development and Malleability from Childhood to Adulthood"  
**IRB No:** H.33.02.06.07.A1

The JHSPH IRB received the amendment request described below on **May 18, 2013**. The IRB reviewed and approved this request on **May 21, 2013**.

This amendment approval is:

- To add Qiana Brown as a student investigator to the study team.

As a reminder, no other changes to this study may be implemented without prior JHSPH IRB review and approval.

The action taken on this study does not change the IRB expiration date, which remains **November 13, 2013**.

If you have any questions regarding this action, please contact the JHSPH IRB Office at (410) 955-3193 or via email at [irboffice@jhsp.edu](mailto:irboffice@jhsp.edu).

JK/rch

JK/rch

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JHSPH IRB Amendment Approval – Expedited Review  
Version #4, 3Mar10

## Appendix B: Curriculum Vitae

### CURRICULUM VITAE

**Qiana Brown**

#### Contact Information

*Mailing Address:*

211 E. Lombard Street  
Suite, 290  
Baltimore, MD 21202  
Phone: (443) 540-4648  
qbrown@jhu.edu

#### EDUCATION AND TRAINING

<u>Degree/Year</u>	<u>Institution</u>	<u>Field</u>
B.A./2007	Auburn University	Psychology
M.P.H./2009	The University of Alabama at Birmingham School of Public Health	Maternal and Child Health
M.S.W./2009	The University of Alabama – Tuscaloosa School of Social Work	Social Work with Children and Families
Ph.D./2014	The Johns Hopkins University Bloomberg School of Public Health	Drug Dependence Epidemiology
Post-doctoral Fellowship (begins 09/2014)	Columbia University Mailman School of Public Health	Substance Abuse Epidemiology

#### Current License

License Graduate Social Worker| Maryland| License Number 17409| Active From  
09/1/2011 to 10/31/2015

## Certificates

Health Disparities and Health Inequalities Certificate – Johns Hopkins Bloomberg School of Public Health 2014

## **PROFESSIONAL EXPERIENCE**

*National Cancer Institute – Cancer Disparities Fellow*

*August 2013-August 2014*

*Department of Oncology, Sidney Kimmel Cancer Center, Center to Reduce Cancer Disparities, Johns Hopkins School of Medicine*

Conduct cancer disparities research, to include manuscript preparation, using a community based participatory research approach

*Chief Research Officer*

*August 2008 – present*

*TVCOFA Corporation*

Majority partner and chief research officer of a certified MBE/DBE corporation, which focuses on technological advances in public health, education, and medical technology

*President and Chief Executive Officer*

*August 2006 – present*

*Jane's House of Inspiration*

Founder, president, and CEO of a multi-state, non-profit, substance abuse treatment program for women and families; develop, evaluate, and implement substance abuse treatment programs; direct a life-skills summer institute for youth aimed at substance abuse prevention; train internal medicine and pediatric medical residents in women's health and urban health with a specific focus on engaging high risk, substance abusing women in primary care

*Research Assistant*

*July 2008 – August 2009*

*Division of Preventive Medicine, University of Alabama at Birmingham*

Assisted with the implementation of the Pilot for the Availability of Social Support (PASS) Study, which examined the role of social support in the lives of African-Americans with heart failure. Responsibilities included participant recruitment, data collection via focus groups and individual interviews, data entry, and qualitative data analysis

*Research Assistant*

*June 2008 – August 2008*

*School of Public Health, The University of Alabama at Birmingham*

Assisted with the implementation of the Helping to Examine African American Relationship Traits (HEART) Study, which focused on the marital quality of African American newlywed couples. Responsibilities included participant recruitment and data collection

*Urban Health Summer Research Intern*

*May 2007 – July 2007*

*School of Public Health, The University of Alabama at Birmingham*

Awarded a competitive summer internship with the Mobile Youth Survey (MYS) to study the origins of risk behaviors among inner-city youth living in poverty, and how contextual factors such as the neighborhood, family, and peer environments influence risk. I assisted with data collection, participant recruitment, and served as team leader where I managed survey administration sites throughout the city.

*Licensed Practical Nurse*

*June 2006 – December 2007*

*East Alabama Medical Center*

Charge nurse for a group of assistant living facilities. Administered medications, and other treatments to facility residents. Managed nursing assistants and auxiliary staff.

*Licensed Practical Nurse*

*June 2004 – July 2006*

*Visiting Nurse Group*

Provided home health care to pediatric patients as a private duty nurse. Maintained equipment such as, ventilators, portable and home oxygen utilities, nebulizer devices, mobility equipment.

*Licensed Practical Nurse*

*June 2003 – June 2004*

*Russell Medical Center*

Provided primary care to pre and post-surgical patients. Assisted health care team in preventing infections, ensuring proper nutrition, and promoting the health and wellness patients.

*Licensed Practical Nurse*

*December 2002 – June 2004*

*Staffing Plus*

Charge nurse at mental health facilities. Served as a patient advocate. Assisted patients with Rehabilitation and provided primary nursing treatment to long-term care patients.

*Licensed Practical Nurse*

*October 2002 – August 2002*

*Maxim Health Care*

Private duty home care nurse for pediatric and geriatric patients.

*Licensed Practical Nurse*

*May 2000 – September 2002*

*Walter Reed Army Medical Center*

Served on active duty in the United States Army as a licensed practical nurse stationed at Walter Reed Army Medical Center. Provided primary nursing care to soldiers and provided support to their families. Cared for patients diagnosed with surgical, psychiatric, orthopedic, pediatric, vascular, and/or oncology disorders. Trained nursing assistants and new graduate practical nurses.

*Active Duty United States Army*

*September 1998 – September 2002*

Performed duties related to protecting America's freedom. Completed basic military training in Ft. Leonard Wood, Missouri. Completed emergency medical technician (EMT) training in Ft. Sam Houston, Texas. Completed nursing school at Walter Reed Army Medical Center.

**PROFESSIONAL ACTIVITIES**

*Society Memberships*

2010 - present                      College for Problems on Drug Dependence

*Participation on Advisory Panels*

2008 – present                      Board Member Jane's House of Inspiration

*Professional Development*

March 2014                      Volunteered at the 38<sup>th</sup> Annual Meeting of the American Society of Preventive Oncology (ASPO)

March 2013                      Teaching at the University Level. Workshop completed at the Johns Hopkins Bloomberg School of Public

June 2011                      Volunteered at the American Family Therapy Academy (AFTA) 33<sup>rd</sup> Annual Meeting

October 2008                      Volunteered at the Council on Social Work Education (CSWE) 54<sup>th</sup> Annual Meeting

March 2008                      Attended a five day training on substance abuse treatment services at the Alabama School of Alcohol and Other Drug Studies (ASADS)

September 2007                      Attended a two day training at the Alabama Poverty Project (APP) on addressing poverty in Alabama

## HONORS AND AWARDS

### *Honors*

2002                      The Army Commendation Medal (ARCOM) for outstanding service and leadership in the United States Army

### *Awards*

2014                      National Institute on Drug Abuse T32 post-doctoral fellowship in substance abuse epidemiology at the Columbia University Mailman School of Public Health (begins 09/2014)

2009 – 2014            National Institute on Drug Abuse T32 pre-doctoral fellowship in drug dependence epidemiology at the Johns Hopkins Bloomberg School of Public Health

2009                      Alabama community service award for work with mothers and daughters sponsored by Lowndes County Public School System of Hayneville, Alabama, Camp Kemet Scholarship Program, and Sisters of the Academy Institute

2008                      Ehney Addison, Jr., and Mildred Fletcher Tillman Camp Endowed Scholarship for graduate studies in social work at The University of Alabama

2008                      Inductee, Golden Key International Honour Society at the University of Alabama at Birmingham

2007                      Inductee, Phi Alpha – International Academic and Service-Based Social Work Honor Society at The University of Alabama

2007                      Inductee, Alpha Epsilon Lambda – National Graduate Student Honor Society at The University of Alabama

2006                      Awarded a competitive internship for women's leadership by the Auburn University Women's Leadership Institute (WLI)



## PUBLICATIONS

### *Journal Articles*

1. **Brown, Q.L.**, Linton, S.L., Harrell, P.T., Mancha, B.E., Alexandre, P.K., Chen, K.F., Eaton, W.W. (2014). The Influence of Religious Attendance on Smoking. *Substance Use and Misuse*, doi:10.3109/10826084.2014.912224
2. Kidwai, R., Mancha, B.E., **Brown, Q.L.**, Eaton, W.W. (2014). The Effect of Spirituality and Religious Attendance on the Relationship Between Psychological Distress and Negative Life Events. *Social Psychiatry and Psychiatric Epidemiology*, 49(3), 487-497.
3. **Brown, Q.L.**, Milam, A.J., Smart, M.J., Johnson, R.M., Linton, S.L., Furr-Holden, C.D.M., Ialongo, N.S. (2014). Objective and Perceived Neighborhood Characteristics and Tobacco Use Among Young Adults. *Drug and Alcohol Dependence*, 134, 370-375.
4. Floyd, L.J., **Brown, Q.** (2013). Attitudes Toward and Sexual Partnerships with Drug Dealers Among Young Adult African American Females in Socially Disorganized Communities. *Journal of Drug Issues*, 43(2), 154-163.
5. Durant, R.W., **Brown Q.L.**, Cherrington, A.L., Andreae, L.J., Hardy, C.M., & Scarinci, I.C. (2013). Social Support Among African Americans with Heart Failure: Is There A Role For Community Health Advisors? *Heart & Lung*, 42(1), 19-25.
6. **Brown, Q.L.**, Cavanaugh, C.E., Penniman, T.V., Latimer, W.W. (2012). The Impact of Homelessness on Recent Sex Trade Among Pregnant Women in Drug Treatment. *Journal of Substance Use*, 17(3), 287-293.

## CURRICULUM VITAE

### **Qiana Brown**

#### PART II

### TEACHING

#### *Classroom Instruction*

October 25, 2013	<i>Guest Lecturer: Public Health In Film and Media (Johns Hopkins University), enrollment 65</i>
Jan 2013 – Mar 2013	<i>Teaching Assistant: Introduction to Behavioral and Psychiatric Genetics (Johns Hopkins School of Public Health), enrollment 25</i>
April 25, 2012	<i>Guest Lecturer: Community Health (Coppin State University School of Education), enrollment 25</i>
Aug 2011 – Oct 2011	<i>Teaching Assistant: Drug and Alcohol Dependence</i>

*Epidemiology (Johns Hopkins University), enrollment 27*

January 8, 2011      *Guest Lecturer: Substance Exposure and Pregnancy  
(University of Maryland School of Social Work),  
enrollment 60*

April 7, 2011      *Guest Lecturer: Cultural Factors in Public Health  
(Johns Hopkins University), enrollment 75*

*Other*

Jan 2013 – Present      *Instructor at Field Placement Site: I instruct medical residents  
from the Medical-Pediatrics Urban Health Primary Care  
Residency Program at the Johns Hopkins University School  
of Medicine during their women's health rotation at  
Jane's House of Inspiration.*

## **PRESENTATIONS**

### *Scientific Meetings*

June 2014      **Brown, Q.**, Milam, A.J, Furr-Holden , D.M. Tobacco outlets and tobacco use in Baltimore City from 2004-2009. Poster presentation at the 76<sup>th</sup> Annual Meeting of the College on Problems of Drug Dependence. San Juan, PR.

March 2014      **Brown, Q.L.**, Mbah, O., Ahmed, S., Pollack, C., Phelan, D., Bowie, J., Bone, L., Wenzel, J., Shapiro, G., Johnson, L., Ford, G. Breast Cancer Screening Among Community Dwelling African American Women 65 and Older: The Role of Patient Navigators. Poster presentation at the 38<sup>th</sup> Annual Meeting of the American Society of Preventive Oncology (ASPO). Arlington, VA.

March 2014      **Brown, Q.L.** Tobacco Outlet Density and Smoking In Young Adulthood. Oral presentation at the Annual Meeting of the NIDA and NIMH Biostatistics and Epidemiology T-32 Training Programs at the Columbia University's Mailman School of Public Health. New York, NY.

June 2013      **Brown, Q.L.**, Milam, A.J., Smart, M.J., Johnson, R.M., Linton, S.L., Furr-Holden, C.D.M., Ialongo, N.S. Association of Objective and Perceived Neighborhood Characteristics with Tobacco Use Among Young Adults. Poster presentation at the 75<sup>th</sup> Annual Meeting of the College on Problems of Drug Dependence. San Diego, CA.

- June 2012      **Brown, Q.L.**, Linton, S. L., Harrell, P.T., Mancha, B.E., Alexandre, P. K., Chen, K. F., Eaton, W.W. The Influence of Religious Attendance on Smoking Behavior Over Time: A Baltimore Epidemiologic Catchment Area (ECA) Study. Poster presentation at the 74<sup>th</sup> Annual Meeting of the College on Problems of Drug Dependence. Palm Springs, CA.
- Oct 2011      **Brown, Q.L.**, Harrell, P.T., Alexandre, P. K., Linton, S. L., Mancha, B., Kidwai, R., Chen, K. F., Eaton, W.W. Religious Activity and Smoking Behavior: A Baltimore Epidemiologic Catchment Area (ECA) Study. Poster presentation at the American Public Health Association 139<sup>th</sup> Annual Meeting and Exposition. Washington, DC.
- June 2010      **Brown, Q.L.**, Cavanaugh, C.E., Penniman, T.V., Latimer, W.W. The Impact of Homelessness on HIV Risk Behavior in Drug Dependent Pregnant Women. Poster presentation at the 72<sup>nd</sup> Annual Meeting of the College on Problems of Drug Dependence. Scottsdale, AZ.
- April 2009      **Britton, Q.L.**, Durant, R.W., Andrea, L.J., Scarinci, I. C. Community Health Advisors' Perspectives On Patients' Needs and Social Support: The Pilot for the Availability of Social Support (PASS) Study. Poster presentation at the 2009 Health Disparities Research Symposium at the University of Alabama at Birmingham. Birmingham, AL.
- Oct 2008      **Britton, Q.L.** Contingency Management: A Standard, Effective, Practical Treatment for Substance Abusing Clients. Oral presentation at the 37<sup>th</sup> Annual Alabama-Mississippi Social Work Education Conference. Auburn, AL.
- May 2007      Bhaju, J., Martin, K., **Britton, Q.**, Day, J., Correia, C. J. An Initial Investigation of Students Violating Alcohol Policies at Home Football Games. Poster presentation at the 19<sup>th</sup> Annual Convention for the Association for Psychological Science. Washington, DC.

## ADDITIONAL INFORMATION

*Personal Statement:* I am an epidemiologist, and a licensed graduate social worker. My research focuses on tobacco and cancer prevention and control, urban health, and substance use disorders among women with a specific emphasis on the role of spirituality and religiousness on recovery. I am also the founder and president of a substance abuse treatment center for women – Jane's House of Inspiration. At my center, I train medical residents, and health educators in urban health and women's health. The client population that I work with is at high-risk for poly-substance abuse, sex trade, and various other risk behaviors, which can lead to a host of health conditions, to include several types of cancers. My goal is to merge my research interests into one complete framework that

accounts for the intersection of exposure to environmental risk (e.g., tobacco outlets) and protective factors (e.g., policy), substance use disorders, and cancer in urban environments. Furthermore, I plan to develop technology to help reduce disparities related to tobacco, cancer, and other drugs.

*Keywords:* Tobacco, Cancer, Urban Health, Environment, Prevention